EXPERIMENTAL

II. EXPERIMENTAL

II.1 POLYFORMALS

The abbreviations used for various chemicals, etc, are presented in table II.1.

1(a) Synthesis of Chelating Polymers using Polyvinyl alcohol and formaldehyde under alkaline condition

Polyvinyl alcohol (KL, SD or LC grade) and water (or glycerine or polyethylene glycol) were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80 °C with occasional shaking. The gel was obtained. It was cured at 90-100 °C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.2(a).

1(b) Synthesis of chelating polymers using polyvinyl alcohol and formaldehyde under acidic condition

Polyvinyl alcohol (KL, SD or LC grade) and water (or glycerine or polyethylene glycol) were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde

Table II.1

Abbreviations

PVA, P - poly vinyl alcohol
F - formaldehyde
W - water
G - glycerine
AG - aqueous glycerine
Pg - poly ethylene glycol
Alc - alcohol
T - toluene
DMF - dimethyl formamide
De - diethylene triamine
Q - 8-hydroxy quinoline
E - ethyl aceto acetate
Sh - salicyl aldehyde
Cl - chloral hydrate
R - resorcinol
Sd - salicylic acid
Am - 4-amino benzoic acid
Ah - p-hydroxy benzoic acid
An - 1-amino-2-naphthol-4-sulphonic acid
e - epichlorhydrin
Gl - glycine
Ap - m-amino phenol
Ad - anthranilic acid

Table II.1 (contd.)

m - melamine

c - starch

B - bisphenol-A

A - acrylamide

EDTA - ethylene diamine tetra acetic acid

M - membrane

KL,K - Koch Light make

SD,S - SD Chem make

LC,L - Loba Chemie make

d.p. - degree of polymerization

a - acidic condition

b - basic condition

s - soluble

i - insoluble

ps - partly soluble

d.e. - degree of extraction

B' - butyraldehyde

Table II.2(a)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Vol of F (ml) 5	Vol of W or G or Pg (ml) 6	Wt of Na_2CO_3 (g) 7	Time of reaction (min) 8	Wt of crude product (g) 9
			(i)	PVA (KL grade)				
1	16A	16KPFb	3	5	20 (W)	3.6	150	5.1
2	19A	19KPFb	3	5	10 (G)	3.6	150	2.7
3	22A	22KPFb	3	5	10 (50% aq G)	3.6	180	3.0
4	25A	25KPFb	3	5	10 (Pg)	3.6	180	2.5
			(ii)	PVA (SD grade)				
5	16A	16SPFb	3	5	20 (W)	3.6	45	3.6
6	19A	19SPFb	3	5	10 (G)	3.6	90	4.4
7	22A	22SPFb	3	5	10 (50% aq G)	3.6	75	3.8
8	25A	25SPFb	3	5	10 (Pg)	3.6	75	3.2

Table II.2(a) (contd.)

1	2	3	4	5	6	7	8	9
			(iii)	PVA (LC grade)				
9	1A	1LPFb	3	1	2 (W)	0.1	180	2.9
10	2A	2LPFb	3	5	2 (W)	0.1	180	3.5
11	3A	3LPFb	3	10	2 (W)	0.1	180	4.8
12	4A	4LPFb	3	15	10 (W)	0.1	480	3.3
13	5A	5LPFb	3	20	10 (W)	0.1	600	5.1
14	6A	6LPFb	3	25	10 (W)	0.1	600	5.3
15	7A	7LPFb	3	25	10 (W)	1.0	600	5.0
16	9A	9LPFb	3	1	5 (W)	0.1	180	2.9
17	10A	10LPFb	3	5	5 (W)	0.1	180	3.5
18	16A	16LPFb	3	5	20 (W)	3.6	60	4.4

and hydrochloric acid were added to the mass. The reaction mixture was heated on water bath at 70-80 °C with occasional shaking. The gel was obtained. It was cured at 90-100 °C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.2(b).

1(c) Synthesis of chelating polymers using polyvinyl alcohol and formaldehyde under alkaline condition followed by acidic condition

Polyvinyl alcohol (KL, SD or LC grade) and water (or glycerine or polyethylene glycol) were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80 °C with occasional shaking for a definite period of time. Then hydrochloric acid was added to the mixture and heating at 70-80 °C was continued further. The gel was obtained. It was cured at 90-100 °C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.2(c).

1(d) Synthesis of chelating polymers using polyvinyl alcohol, starch and formaldehyde under alkaline condition

Polyvinyl alcohol (KL or SD grade) and water (or glycerine or polyethylene glycol) were taken in 250 ml round bottom

Table II.2(b)

No. 1	Expt 2	Product 3	Wt of PVA (g) 4	Vol of F (ml) 5	Vol of W or G or Pg (ml) 6	Vol of HCl (ml) 7	Time of reaction (min) 8	Wt of crude product (g) 9
				(i) PVA (KL grade)				
1	13A	13KPFa	3	5	15 (W)	1.0	80	3.3
2	17A	17KPFa	3	5	20 (W)	6.5	30	3.3
3	20A	20KPFa	3	5	10 (G)	6.5	30	8.7
4	23A	23KPFa	3	5	10 (50% aq G)	6.5	60	6.2
5	26A	26KPFa	3	5	10 (Pg)	6.5	30	6.8

Table II.2(b) (contd.)

1	2	3	4	5	6	7	8	9
				(ii)	PVA (SD grade)			
6	13A	13SPFa	3	5	5 (W)	1.0	15	3.6
7	17A	17SPFa	3	5	10 (W)	6.5	20	3.8
8	20A	20SPFa	3	5	10 (G)	6.5	30	5.3
9	23A	23SPFa	3	5	10 (50% aq G)	6.5	60	3.8
10	26A	26SPFa	3	5	10 (Pg)	6.5	50	3.4
				(iii)	PVA (LC grade)			
11	8A	8LPFa	3	25	10 (W)	1.0	60	3.8
12	12A	12LPFa	3	1	5 (W)	1.0	180	3.2
13	13A	13LPFa	3	5	5 (W)	1.0	180	3.6
14	17A	17LPFa	3	5	10 (W)	6.5	20	4.5

Table II.2(c)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Vol of F (ml) 5	Vol of W or G or Pg (ml) 6	Wt of Na_2CO_3 (g) 7	Time of reaction (i) (min) 8	Vol of HCl (ml) 9	Time of reaction (ii) (min) 10	Wt of crude product (g) 11
(i) PVA (KL grade)										
1	14A	14KPFba	3	1	15 (W)	0.1	35	1.0	25	2.9
2	15A	15KPFba	3	5	15 (W)	0.1	35	1.0	25	3.6
3	18A	18KPFba	3	5	20 (W)	3.6	40	6.5	120	2.8
4	21A	21KPFba	3	5	10 (G)	3.6	45	6.5	15	3.0
5	24A	24KPFba	3	5	10 (50% aq G)	3.6	60	6.5	120	2.8
6	27A	27KPFba	3	5	10 (Pg)	3.6	60	6.5	120	3.6

Table II.2(c) (contd.)

1	2	3	4	5	6	7	8	9	10	11
					(ii) **PVA (SD grade)**					
7	14A	14SPFba	3	1	5 (W)	0.1	15	1.0	5	3.4
8	15A	15SPFba	3	5	5 (W)	0.1	15	1.0	5	4.7
9	18A	18SPFba	3	5	20 (W)	3.6	30	6.5	15	3.6
10	21A	21SPFba	3	5	10 (G)	3.6	60	6.5	30	3.9
11	24A	24SPFba	3	5	10 (50% aq G)	3.6	60	6.5	15	3.7
12	27A	27SPFba	3	5	10 (Pg)	3.6	60	6.5	30	2.2
					(iii) **PVA (LC grade)**					
13	11A	11LPFba	3	25	10 (W)	1.0	60	1.0	120	5.1
14	14A	14LPFba	3	1	5 (W)	0.1	60	1.0	120	5.5
15	15A	15LPFba	3	5	5 (W)	0.1	60	1.0	120	5.6
16	18A	18LPFba	3	5	20 (W)	3.6	15	6.5	30	3.7

flask fitted with reflux condenser. Starch, formaldehyde and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking. The gel was obtained. It was cured at 90-100°C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.2(d).

1(e) Synthesis of chelating polymers using polyvinyl alcohol, starch and formaldehyde under acidic condition

Polyvinyl alcohol (KL or SD grade) and water (or glycerine or polyethylene glycol) were taken in 250 ml round bottom flask fitted with reflux condenser. Starch, formaldehyde and hydrochloric acid were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking. The gel was obtained. It was cured at 90-100°C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.2(e).

1(f) Synthesis of chelating polymers using polyvinyl alcohol, starch and formaldehyde under alkaline condition followed by acidic condition

Polyvinyl alcohol (KL or SD grade) and water (or glycerine or polyethylene glycol) were taken in 250 ml

Table II.2(d)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Wt of starch (c) (g) 5	Vol of F (ml) 6	Vol of W or G or Pg (ml) 7	Wt of Na_2CO_3 (g) 8	Time of reaction (min) 9	Wt of crude product (g) 10
				(i)	PVA (KL grade)				
1	16A'	16KPFcb	3	3	5	25 (W)	3.6	180	2.9
2	19A'	19KPFcb	3	3	5	10 (G)	3.6	180	2.9
3	22A'	22KPFcb	3	3	5	10 (50% aq G)	3.6	180	2.9
4	25A'	25KPFcb	3	3	5	10 (Pg)	3.6	180	3.7
				(ii)	PVA (SD grade)				
5	16A'	16SPFcb	3	3	5	25 (W)	3.6	120	3.6
6	19A'	19SPFcb	3	3	5	10 (G)	3.6	120	3.8
7	22A'	22SPFcb	3	3	5	10 (50% aq G)	3.6	90	3.8
8	25A'	25SPFcb	3	3	5	10 (Pg)	3.6	150	2.1

Table II.2(e)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Wt of starch (c) (g) 5	Vol of F (ml) 6	Vol of W or G or Pg (ml) 7	Vol of HCl (ml) 8	Time of reaction (min) 9	Wt of crude product (g) 10
				(i)	PVA (KL grade)				
1	13A'	13KPFca	3	3	5	25 (W)	1.0	180	3.6
2	17A'	17KPFca	3	3	5	25 (W)	6.5	180	3.9
3	20A'	20KPFca	3	3	5	10 (G)	6.5	90	11.2
4	23A'	23KPFca	3	3	5	10 (50% aq G)	6.5	60	6.0
5	26A'	26KPFca	3	3	5	10 (Pg)	6.5	60	8.2
				(ii)	PVA (SD grade)				
6	13A'	13SPFca	3	3	5	25 (W)	1.0	120	3.3
7	17A'	17SPFca	3	3	5	25 (W)	6.5	120	3.2
8	20A'	20SPFca	3	3	5	10 (G)	6.5	60	3.6
9	23A'	23SPFca	3	3	5	10 (50% aq G)	6.5	120	3.4
10	26A'	26SPFca	3	3	5	10 (Pg)	6.5	60	3.3

round bottom flask fitted with reflux condenser. Starch, formaldehyde and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking. Then hydrochloric acid was added to the above mixture and heating at 70-80°C was continued further. The gel was obtained. It was cured at 90-100°C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.2(f).

All these products (II.1) were washed with acid, alkali, acid, water, acetone and alcohol respectively and dried. The solubility of all these products (II.1) has been studied in different solvents and the data for some of them are presented in table II.3.

II.2 CHELATING POLYFORMALS

2(a) Synthesis of chelating polymers, using polyvinyl alcohol, formaldehyde and 8-hydroxy quinoline

Polyvinyl alcohol (KL, SD or LC grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser and formaldehyde and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for a definite period of time. Then 8-hydroxy quinoline dissolved in requisite amount of hydrochloric acid was added to the above

Table II.2(f)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Wt of starch (c) (g) 5	Vol of F (ml) 6	Vol of W or G or Pg (ml) 7	Wt of Na_2CO_3 (g) 8	Time of reaction (min) 9	Vol of HCl (ml) 10	Time of reaction (min) 11	Wt of crude product (g) 12
					(i)	PVA (KL grade)					
1	14A'	14KPFcba	3	3	1	25 (W)	0.1	60	1.0	120	3.5
2	15A'	15KPFcba	3	3	5	25 (W)	0.1	60	1.0	120	3.6
3	18A'	18KPFcba	3	3	5	25 (W)	3.6	60	6.5	120	2.6
4	21A'	21KPFcba	3	3	5	10 (G)	3.6	60	6.5	120	2.9
5	24A'	24KPFcba	3	3	5	10 (50% aq G)	3.6	60	6.5	120	2.9
6	27A'	27KPFcba	3	3	5	10 (Pg)	3.6	120	6.5	60	4.2

Table II.2(f) (contd.)

1	2	3	4	5	6	7	8	9	10	11	12
					(ii)	PVA (SD grade)					
7	14A'	14SPFcba	3	3	1	25 (W)	0.1	60	1.0	60	3.4
8	15A'	15SPFcba	3	3	5	25 (W)	0.1	60	1.0	60	3.4
9	18A'	18SPFcba	3	3	5	25 (W)	3.6	90	6.5	60	3.8
10	21A'	21SPFcba	3	3	5	10 (G)	3.6	60	6.5	60	3.1
11	24A'	24SPFcba	3	3	5	10 (50% aq G)	3.6	60	6.5	30	3.3
12	27A'	27SPFcba	3	3	5	10 (Pg)	3.6	60	6.5	90	2.8

Table II.3 (contd)

1	2	3	4	5	6	7	8	9	10
				b(iii) PVA (LC grade)					
6	17A	17LPFa	white	p	p	i	i	i	i
				c(i) PVA (KL grade)					
7	18A	18KPFba	light brown	p	p	i	i	i	i
				c(ii) PVA (SD grade)					
8	18A	18SPFba	white	p	p	i	i	i	i
				c(iii) PVA (LC grade)					
9	18A	18LPFba	brown	p	p	i	i	i	i
				d(i) PVA (KL grade)					
10	16A'	16KPFcb	white	p	p	i	i	i	i

Table II.3 (contd)

1	2	3	4	5	6	7	8	9	10
				d(ii) PVA (SD grade)					
11	16A'	16SPFcb	white	p	p	i	i	i	i
				e(i) PVA (KL grade)					
12	17A'	17KPFca	light brown	p	p	i	i	i	i
				e(ii) PVA (SD grade)					
13	17A'	17SPFca	white	p	p	i	i	i	i
				f(i) PVA (KL grade)					
14	18A'	18KPFcba	white	p	p	i	i	i	i
				f(ii) PVA (SD grade)					
15	18A'	18SPFcba	brown	p	p	i	i	i	i

mixture and heating at 70-80°C was continued further. The gel was obtained. It was cured at 90-100°C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amount of reactants used, time of reaction, yield of the product, etc, are given in the table II.4(a).

2(b) Synthesis of chelating polymers using polyvinyl alcohol, starch, formaldehyde and 8-hydroxy quinoline

Polyvinyl alcohol (KL or SD grade) was taken in 250ml round bottom flask fitted with reflux condenser. Starch, formaldehyde and sodium carbonate solutions were added to it. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for a definite period of time. Then 8-hydroxy quinoline dissolved in requisite amount of hydrochloric acid was added to the above mixture and heating at 70-80°C was continued further. The gel was obtained. It was cured at 90-100°C for 24 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(b).

2(c) Synthesis of chelating polymers using polyvinyl alcohol and ethyl acetoacetate under alkaline condition

Polyvinyl alcohol (KL, SD or LC grade) was mixed with water in presence or absence of starch in 250 ml

Table II.4(a)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Vol of F (ml) 5	Wt of Na_2CO_3 (g) 6	Time of reaction (i) (min) 7	Wt of 8-hydroxy quinoline (Q) (g) 8	Time of reaction (ii) (min) 9	Wt of crude product (g) 10
(i) PVA (KL grade)									
1	5C	5KPFQb	3	1	0.1	15	0.5	15	4.7
2	6C	6KPFQb	3	5	0.1	15	1.0	15	6.7
3	7C	7KPFQb	3	5	0.1	30	3.0	20	6.9
(ii) PVA (SD grade)									
4	5C	5SPFQb	3	1	0.1	20	0,5	10	3.9
5	6C	6SPFQb	3	5	0.1	20	1.0	10	6.5
6	7C	7SPFQb	3	5	0.1	25	3.0	20	7.6

Table II.4(a) (contd.)

1	2	3	4	5	6	7	8	9	10
				(iii)	PVA (LC grade)				
7	1C	1LPFQb	3	25	0.1	120	0.5	30	9.4
8	2C	2LPFQb	3	20	0.1	120	0.5	40	5.3
9	3C	3LPFQb	3	15	0.1	90	0.5	30	4.3
10	4C	4LPFQb	3	5	0.1	75	0.5	30	3.9
11	5C	5LPFQb	3	1	0.1	40	0.5	95	3.0
12	6C	6LPFQb	3	5	0.1	60	1.0	30	3.5
13	7C	7LPFQb	3	5	0.1	60	3.0	45	5.2
14	8C	8LPFQb	3	5	0.1	60	5.0	75	8.9

Table II.4(b)

No	Expt	Product	Wt of PVA (g)	Wt of starch (c) (g)	Vol of F (ml)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Wt of 8-hydroxy quinoline (Q) (g)	Time of reaction (ii) (min)	Wt of crude product (g)
					(i) PVA (KL grade)					
1	5C'	5KPFQcb	3	3	1	0.1	45	0.5	30	3.4
2	6C'	6KPFQcb	3	3	5	0.1	45	1.0	40	6.4
3	7C'	7KPFQcb	3	3	5	0.1	45	3.0	30	7.5
					(ii) PVA (SD grade)					
4	5C'	5SPFQcb	3	3	1	0.1	60	0.5	60	3.4
5	6C'	6SPFQcb	3	3	5	0.1	60	1.0	60	6.1
6	7C'	7SPFQcb	3	3	5	0.1	60	3.0	60	6.2

round bottom flask fitted with reflux condenser and ethyl acetoacetate and sodium carbonate solution were added to the mass. The reaction mixture was heated on water bath at 70-80 °C with occasional shaking. The gel was obtained. It was cured at room temperature and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(c).

2(d) Synthesis of chelating polymers using polyvinyl alcohol and ethyl acetoacetate under acidic condition

Polyvinyl alcohol (KL, SD or LC grade) was mixed with water in presence or absence of starch in 250 ml round bottom flask fitted with reflux condenser and ethyl acetoacetate and hydrochloric acid were added to the mass. The reaction mixture was heated on water bath at 70-80 °C with occasional shaking. The gel was obtained. It was cured at room temperature and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(d).

2(e) Synthesis of chelating polymers using polyvinyl alcohol and ethyl acetoacetate, initially under alkaline condition followed by acidic condition

Polyvinyl alcohol (KL, SD or LC grade) was mixed with water in presence or absence of starch in 250 ml

Table II.4(c)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Wt of starch (c) (g) 5	Vol of ethyl aceto-acetate (E) (ml) 6	Wt of Na_2CO_3 (g) 7	Time of reaction (min) 8	Wt of crude product (g) 9
				(i) PVA (KL grade)				
1	3E	3KPEb	3	-	2	1	180	4.3
2	3E'	3KPEcb	3	3	2	1	240	5.3
				(ii) PVA (SD grade)				
3	3E	3SPEb	3	-	2	1	50	4.7
4	3E'	3SPEcb	3	3	2	1	240	7.4

Table II.4(c) (contd.)

1	2	3	4	5	6	7	8	9
			(iii)	PVA (LC grade)				
5	1E	1LPEb	3	-	1	1	105	4.1
6	3E	3LPEb	3	-	2	1	105	4.3
7	6E	6LPEb	3	-	10	1	60	4.0
8	8E	8LPEb	3	-	20	1	60	3.4

Table II.4(d)

No. 1	Expt 2	Product 3	Wt of PVA (g) 4	Wt of starch (c) (g) 5	Vol of ethyl aceto-acetate (E) (ml) 6	Vol of HCl (ml) 7	Time of reaction (min) 8	Wt of crude product (g) 9
			(i)	PVA (KL grade)				
1	4E	4KPEa	3	-	2	1	180	2.7
2	4E'	4KPEca	3	3	2	1	240	4.1
			(ii)	PVA (SD grade)				
3	4E	4SPEa	3	-	2	1	145	2.3
4	4E'	4SPEca	3	3	2	1	300	5.1

Table II.4(d) (contd.)

1	2	3	4	5	6	7	8	9
			(iii)	PVA (LC grade)				
5	2E	2LPEa	3	-	1	1	135	4.2
6	4E	4LPEa	3	-	2	1	150	4.8
7	7E	7LPEa	3	-	10	1	60	4.3
8	9E	9LPEa	3	-	20	1	60	3.6

round bottom flask fitted with reflux condenser and ethyl acetoacetate and sodium carbonate solution were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking. Then hydrochloric acid was added to the above mixture and heating at 70-80°C was continued further. The gel was obtained. It was cured at room temperature and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(e).

2(f) Synthesis of chelating polymers using polyvinyl alcohol and salicyl aldehyde under alkaline condition

Polyvinyl alcohol (LC grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Salicyl aldehyde and sodium carbonate solution were added to the mass. The reaction mixture was heated on the water bath at 70-80°C with occasional shaking. Yellow coloured gel was obtained, which turned black on standing at room temperature. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(f).

2(g) Synthesis of chelating polymers using polyvinyl alcohol and salicyl aldehyde under acidic condition

Polyvinyl alcohol (KL, SD or LC grade) was mixed with water (or alcohol) in presence or absence of starch in 250 ml round bottom flask fitted with reflux condenser.

Table II.4(e)

No	Expt	Product	Wt of PVA (g)	Wt of starch (c) (g)	Vol of ethyl aceto-acetate (E) (ml)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Vol of HCl (ml)	Time of reaction (ii) (min)	Wt of crude product (g)
					(i)	PVA (KL grade)				
1	5E	5KPEba	3	-	1	1	30	1	270	4.4
2	5E'	5KPEcba	3	3	1	1	60	1	180	6.2
					(ii)	PVA (SD grade)				
3	5E	5SPEba	3	-	1	1	60	1	60	3.0
4	5E'	5SPEcba	3	3	1	1	60	1	180	5.2
					(iii)	PVA (LC grade)				
5	5E	5LPEba	3	-	1	1	60	1	90	4.6

Table II.4(f)

No	Expt	Product	Wt of PVA (g)	Vol of salicyl aldehyde (Sh) (ml)	Wt of Na_2CO_3 (g)	Time of reaction (min)	Wt of crude product (g)
PVA (LC grade)							
1	1F	1LPShb	3	1	1	45	3.9

Salicyl aldehyde and hydrochloric acid were added to the mass. The reaction mixture was heated on the water bath at 70-80 °C with occasional shaking. The gel was obtained. It was cured at 90-100 °C for 6 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The gel obtained was pink in colour, but turned black on standing. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(g).

2(h) Synthesis of chelating polymers using polyvinyl alcohol and chloral hydrate under alkaline condition

Polyvinyl alcohol (LC grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Chloral hydrate and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80 °C with occasional shaking. The gel was obtained. It was cured at 90-100 °C for 4 to 4½ hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(h).

2(j) Synthesis of chelating polymers using polyvinyl alcohol and chloral hydrate under acidic condition

Polyvinyl alcohol (LC grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Chloral hydrate and hydrochloric acid were added to the mass. The reaction mixture was heated on water bath at

Table II.4(g)

No 1	Expt 2	Product 3	Wt of PVA (g) 4	Wt of starch (c) (g) 5	Vol of salicyl aldehyde (Sh) (ml) 6	Vol of W or Alc (ml) 7	Vol of HCl (ml) 8	Time of reaction (min) 9	Wt of crude product (g) 10
(i) PVA (KL grade)									
1	6F	6KPSha	3	-	2	15 (50% aq Alc)	1	180	4.8
2	6F'	6KPShca	3	3	2	25 (50% aq Alc)	1	300	5.4
(ii) PVA (SD grade)									
3	4F	4SPSha	3	-	1	-	1	15	2.7
4	5F	5SPSha	3	-	2	10 (W)	1	60	4.6
5	6F	6SPSha	3	-	2	10 (50% aq Alc)	1	60	4.1
6	8F	8SPSha	3	-	5	10 (W)	1	60	5.7
7	9F	9SPSha	3	-	5	10 (50% aq Alc)	1	60	6.2
8	11F	11SPSha	3	-	5	10 (50% aq Alc)	2	45	6.2
9	6F'	6SPShca	3	3	2	25 (50% aq Alc)	1	150	7.4

Table II.4(g) (contd.)

1	2	3	4	5	6	7	8	9	10
					(iii) PVA (LC grade)				
10	2F	2LPSha	3	-	1	10 (W)	1	60	3.9
11	3F	3LPSha	3	-	1	10 (Alc)	1	60	4.1
12	4F	4LPSha	3	-	1	-	1	15	3.5
13	5F	5LPSha	3	-	2	10 (W)	1	60	4.7
14	6F	6LPSha	3	-	2	10 (Alc)	1	60	5.3
15	7F	7LPSha	3	-	2	-	1	15	3.9
16	8F	8LPSha	3	-	5	10 (W)	1	70	5.8
17	9F	9LPSha	3	-	5	10 (Alc)	1	80	6.0
18	10F	10LPSha	3	-	5	-	1	20	4.9

Table II.4(h)

No	Expt	Product	Wt of PVA (g)	Wt of chloral hydrate (Cl) (g)	Wt of Na_2CO_3 (g)	Time of reaction (min)	Wt of crude product (g)
PVA (LC grade)							
1	1H	1LPClb	3	1	0.1	180	3.5
2	3H	3LPClb	3	1	1.0	60	3.8
3	4H	4LPClb	3	2	0.1	360	3.7
4	9H	9LPClb	3	5	0.5	150	3.5

70-80°C with occasional shaking. The gel was obtained. It was cured at 90-100°C for 4 to 4½ hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(j).

2(k) Synthesis of chelating polymers using polyvinyl alcohol and chloral hydrate initially under alkaline condition followed by acidic condition

Polyvinyl alcohol (LC grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Chloral hydrate and sodium carbonate solution were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking. Then hydrochloric acid was added to the above mixture and heating at 70-80°C was continued further. The gel was obtained. It was cured at 90-100°C for 4 hours and weighed. It was washed with water and alcohol, dried and then used for investigations. The amounts of reactants used, time of reaction, wt of the crude product, etc, are given in the table II.4(k).

All these products (II).2) were washed with acid, alkali, acid, water, acetone and alcohol respectively and dried. The solubility of these products has been studied in different solvents and the data for some of them are presented in tables II.5.

Table II.4(j)

No	Expt	Product	Wt of PVA (g)	Wt of chloral hydrate (Cl) (g)	Vol of HCl (ml)	Time of reaction (min)	Wt of crude product (g)
PVA (LC grade)							
1	2H	2LPCla	3	1	1	180	3.7
2	5H	5LPCla	3	2	1	180	3.9
3	7H	7LPCla	3	2	3	120	3.6
4	8H	8LPCla	3	5	3	150	5.3

Table II.4(k)

No.	Expt	Product	Wt of PVA (g)	Wt of chloral hydrate (Cl) (g)	Wt of Na_2CO_3 (g)	Time of reaction (I) (min)	Vol of HCl (ml)	Time of reaction (II) (min)	Wt of crude product (g)
PVA (LC grade)									
1	6H	6LPClba	3	2	0.1	30	1	120	3.4

Table II.5

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	2	3	4	5	6	7	8	9	10
				a(i) PVA (KL grade)					
1	5C	5KPFQb	brown	p	p	i	i	i	i
2	7C	7KPFQb	yellow	p	p	i	i	i	i
				a(ii) PVA (SD grade)					
3	7C	7SPFQb	yellow	p	p	i	i	i	i
				a(iii) PVA (LC grade)					
4	5C	5LPFQb	yellow	p	p	i	i	i	i
5	7C	7LPFQb	red	p	p	i	i	i	i

Table II.5 (contd)

1	2	3	4	5	6	7	8	9	10
				b(i) PVA (KL grade)					
6	5C'	5KPFQcb	yellowish brown	p	p	i	i	i	i
7	7C'	7KPFQcb	reddish brown	p	p	i	i	i	i
				b(ii) PVA (SD grade)					
8	5C'	5SPFQcb	yellowish brown	p	p	i	i	i	i
9	7C'	7SPFQcb	reddish brown	p	p	i	i	i	i
				c(i) PVA (KL grade)					
10	3E	3KPEb	light brown	p	p	i	i	i	i
11	3E'	3KPEcb	light brown	p	p	i	i	i	i

Table II.5 (contd)

1	2	3	4	5	6	7	8	9	10
				c(ii) PVA (SD grade)					
12	3E	3SPEb	brown	p	p	i	i	i	i
13	3E'	3SPEcb	light brown	p	p	i	i	i	i
				c(iii) PVA (LC grade)					
14	3E	3LPEb	brown	p	p	i	i	i	i
				d(i) PVA (KL grade)					
15	4E	4KPEa	black	p	p	i	i	i	i
16	4E'	4KPEca	light brown	p	p	i	i	i	i
				d(ii) PVA (SD grade)					
17	4E	4SPEa	black	p	p	i	i	i	i
18	4E'	4SPEca	black	p	p	i	i	i	i

Table II.5 (contd)

1	2	3	4	5	6	7	8	9	10
				d(iii) PVA (LC grade)					
19	4E	4LPEa	brown	p	p	i	i	i	i
				e(i) PVA (KL grade)					
20	5E	5KPEba	brown	p	p	i	i	i	i
21	5E'	5KPEcba	brown	p	p	i	i	i	i
				e(ii) PVA (SD grade)					
22	5E	5SPFba	brown	p	p	i	i	i	i
23	5E'	5SPEcba	brown	p	p	i	i	i	i
				e(iii) PVA (LC grade)					
24	5E	5LPEba	brown	p	p	i	i	i	i

Table II.5 (contd)

1	2	3	4	5	6	7	8	9	10
				f PVA (LC grade)					
25	1F	1LPShb	black	p	p	i	i	i	i
				g(i) PVA (KL grade)					
26	6F	6KPSha	black	p	p	i	i	i	i
27	6F'	6KPShca	black	p	p	i	i	i	i
				g(ii) PVA (SD grade)					
28	6F	6SPSha	black	p	p	i	i	i	i
29	6F'	6SPShca	black	p	p	i	i	i	i
				g(iii) PVA (LC grade)					
30	6F	6LPSha	black	p	p	i	i	i	i

Table II.5 (contd)

1	2	3	4	5	6	7	8	9	10
				h PVA (LC grade)					
31	3H	3LPClb	light brown	p	p	i	i	i	i
32	4H	4LPClb	brown	p	p	i	i	i	i
				j PVA (LC grade)					
33	5H	5LPCla	white	p	p	i	i	i	i
34	7H	7LPCla	brown	p	p	i	i	i	i
				k PVA (LC grade)					
35	6H	6LPClba	brown	p	p	i	i	i	i

II.3 CHELATING POLYFORMALS - FURTHER RESINIFICATION

3(a) Synthesis of chelating polymers using polyvinyl alcohol formaldehyde and resorcinol

Polyvinyl alcohol (KL grade) was mixed with glycerine (or polyethylene glycol) in presence or absence of starch in 250 ml round bottom flask fitted with reflux condenser and formaldehyde and sodium carbonate solutions were added to the mass. The reaction mixture was heated on the water bath at 70-80 °C with occasional shaking. Resorcinol and additional amount of formaldehyde were added to the above mixture and heating at 70-80 °C was continued further. The gel was obtained. It was cured at 90-100 °C, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, time of curing, yield of the product, etc, are given in the table II.6(a).

3(b) Synthesis of chelating polymers using polyvinyl alcohol, formaldehyde, 8-hydroxy quinoline and resorcinol

Polyvinyl alcohol (KL grade) was mixed with water in presence or absence of starch in 250 ml round bottom flask fitted with reflux condenser and formaldehyde and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80 °C with occasional shaking. Resorcinol and additional amount of formaldehyde

Table II.6(a)

Wt of PVA (KL grade) : 3 g
Vol of F : 5 ml
Vol of G or Pg : 10 ml
Wt of Na_2CO_3 : 3.6 g
Additional vol of F : 5 ml

No	Expt	Product	Wt of starch (c) (g)	G or Pg	Time of raction (I) (min)	Wt of resorcinol (R) (g)	Time of reaction (II) (min)	Time of curing (hr)	Wt of product (g)
1	19AR	19KPFR	-	G	30	1.0	30	24	5.9
2	25AR	25KPFR	-	Pg	30	1.0	60	24	5.2
3	19A(R)$_{0.5}$	19KPFR'	-	G	30	0.5	90	24	3.1
4	25A(R)$_{0.5}$	25KPFR'	-	Pg	30	0.5	70	24	3.1
5	19A'R	19KPFRc	3	G	60	1.0	120	21	8.9
6	25A'R	25KPFRc	3	Pg	60	1.0	120	17	6.2
7	19A'(R)$_{0.5}$	19KPFR'c	3	G	60	0.5	45	24	3.5
8	25A'(R)$_{0.5}$	25KPFR'c	3	Pg	60	0.5	60	24	3.2

were added to the above mixture and it was heated for 3-5 minutes. 8-hydroxy quinoline dissolved in hydrochloric acid was added to it and heating at 70-80°C was continued further. The gel was obtained. It was cured at 90-100°C, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, time of curing, yield of the product, etc, are given in the table II.6(b).

3(c) Synthesis of chelating polymers using polyvinyl alcohol, ethyl acetoacetate, formaldehyde and resorcinol

Polyvinyl alcohol (KL grade) was mixed with water in presence or absence of starch in 250 ml round bottom flask fitted with reflux condenser and ethyl acetoacetate and sodium carbonate solutioh were added to the mass. The reaction mixture was heated on the water bath at 70-80°C with occasional shaking. Resorcinol and formaldehyde (with or without HCl) were added to the above mixture and heating at 70-80°C was continued further. The gel obtained was cured at 90-100°C, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amount of reactants used, time of reaction, time of curing, yield of the product, etc, are given in the table II.6(c).

Table II.6(b)

Wt of PVA (KL grade) : 3 g

Wt of Na_2CO_3 : 0.1 g

Wt of resorcinol (R) : 1 g

Additional vol of F : 5 ml

No	Expt	Product	Wt of starch (c) (g)	Vol of F (ml)	Time of reaction (I) (min)	Wt of 8-hydroxy quinoline (Q) (g)	Time of reaction (II) (min)	Time of curing (hr)	Wt of product (g)
1	5CR	5KPFQR	–	1	30	0.5	30	10	5.7
2	6CR	6KPFQR	–	5	30	1.0	30	10	6.6
3	7CR	7KPFQR	–	5	30	3.0	50	17	9.9
4	5C'R	5KPFQRc	3	1	60	0.5	90	17	8.5
5	6C'R	6KPFQRc	3	5	60	1.0	90	17	9.9
6	7C'R	7KPFQRc	3	5	60	3.0	90	22	12.0

Table II.6(c)

Wt of PVA (KL grade) : 3 g
Wt of Na_2CO_3 : 1 g
Wt of resorcinol (R) : 1 g
Vol of F : 5 ml

No	Expt	Product	Wt of starch (c) (g)	Vol of ethyl aceto-acetate (E) (ml)	Time of reaction (i) (min)	Vol of HCl (ml)	Time of reaction (ii) (min)	Time of curing (hr)	Wt of product (g)
1	3ER	3KPERF	-	2	60	-	120	22	10.1
2	5ER	5KPERF	-	1	60	1	120	17	6.5
3	3E'R	3KPERFc	3	2	60	-	120	14	11.8
4	5E'R	5KPERFc	3	1	60	1	120	10	9.2

3(d) Synthesis of chelating polymers using polyvinyl alcohol, chloral hydrate, formaldehyde and resorcinol

Polyvinyl alcohol (KL grade) was mixed with water in presence or absence of starch in 250 ml round bottom flask fitted with reflux condenser and chloral hydrate and sodium carbonate solutions were added to the mass. The reaction mixture was heated on the water bath at 70-80°C with occasional shaking. Resorcinol and formaldehyde were added to the above mixture and heating at 70-80°C was continued further. The gel was obtained. It was cured at 90-100°C, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, time of curing, yield of the product, etc, are given in the table II.6(d).

The solubility of all these products (II.3) has been studied in different solvents and the data are presented in table II.7.

II.4 SORPTION AND ION EXCHANGE STUDIES

4(a) Conversion of resins into H-form

Approximately 5.0 g of resin were taken in the flask. 1 litre of 1N hydrochloric acid was added to it and kept with occasional shaking for 24 hours to convert it into H-form. The resin was filtered, washed to neutrality with water and dried at room temperature.

Table II.6(d)

Wt of PVA (KL grade) : 3 g
Wt of chloral hydrate (Cl) : 1 g
Wt of resorcinol (R) : 1 g
Vol of F : 5 ml

No	Expt	Product	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (I) (min)	Time of reaction (II) (min)	Time of curing (hr)	Wt of product (g)
1	1HR	1KPClRF	–	0.1	60	360	9	5.9
2	3HR	3KPClRF	–	1.0	60	120	17	5.6
3	1H'R	1KPClRFc	3	0.1	60	300	14	6.7
4	3H'R	3KPClRFc	3	1.0	60	120	10	6.9

Table II.7

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	2	3	4	5	6	7	8	9	10
				a. PVA (KL grade)					
1	25AR	25KPFR	reddish brown	i	i	i	i	i	i
2	25A(R)$_{0.5}$	25KPFR'	reddish brown	p	p	i	i	i	i
3	25A'R	25KPFRc	brown	i	i	i	i	i	i
4	25A'(R)$_{0.5}$	25KPFR'c	reddish brown	p	p	i	i	i	i
				b. PVA (KL grade)					
5	6CR	6KPFQR	red	i	i	i	i	i	i
6	6C'R	6KPFQRc	orange	i	i	i	i	i	i

Table II.7 (contd)

1	2	3	4	5	6	7	8	9	10
				c. PVA (KL grade)					
7	5ER	5KPERF	black	i	i	i	i	i	i
8	5E'R	5KPERFc	reddish brown	i	i	i	i	i	i
				d. PVA (KL grade)					
9	3HR	3KPC1RF	brown	i	i	i	i	i	i
10	3H'R	3KPC1RFc	reddish brown	i	i	i	i	i	i

H-form of the resin having 35-100 BSS mesh size was used for studying water content of resin, % sorption in water and saline solution, uptake of Cu, Ni and Zn ions, etc.

4(b) Water content of resins

Water content of the resin was determined by drying exactly weighed (H-form) resin at 100-110°c for 24 hours and reweighing it after cooling it in a desiccator. The calculation is as follows:

$$\frac{\text{Wt of dried resin} \times 100}{\text{Wt of resin before drying}} = \%\ \text{solid}$$

$$100 - \%\ \text{solid} = \%\ \text{water}$$

The observation for the resins presented in II.3 are presented in tables II.8

4(c) Percentage sorption by resin from water and saline solutions

0.2 g (exactly weighed) H-form of the resin was taken in a dry 250 ml glass stoppered bottle. To the sample in the bottle were added 50 ml of distilled water (or NaCl solution). The mixture was kept for 24 hours with occasional shaking. It was filtered till the water got completely drained and reweighed it without allowing it to dry.

Table II.8(a)

No	Expt	Product	Water Content %	Solid content %
			PVA (KL grade)	
1	19AR	19KPFR	13.5	86.5
2	25AR	25KPFR	12.0	88.0
3	19A(R)$_{0.5}$	19KPFR'	4.1	95.9
4	25A(R)$_{0.5}$	25KPFR'	5.3	94.7
5	19A'R	19KPFRc	17.0	83.0
6	25A'R	25KPFRc	17.5	82.5
7	19A'(R)$_{0.5}$	19KPFR'c	4.4	95.6
8	25A'(R)$_{0.5}$	25KPFR'c	5.8	94.2

Table II.8(b)

No	Expt	Product	Water content %	Solid content %
			PVA (KL grade)	
1	5CR	5KPFQR	18.0	82.0
2	6CR	6KPFQR	18.5	81.5
3	7CR	7KPFQR	14.5	85.5
4	5C'R	5KPFQRc	11.0	89.0
5	6C'R	6KPFQRc	17.5	82.5
6	7C'R	7KPFQRc	15.5	84.5

Table II.8(c)

No	Expt	Product	Water content %	Solid content %
		PVA (KL grade)		
1	3ER	3KPERF	31.0	69.0
2	5ER	5KPERF	26.0	74.0
3	3E'R	3KPERFc	25.0	75.0
4	5E'R	5KPERFc	22.5	77.5

Table II.8(d)

No	Expt	Product	Water content %	Solid content %
		PVA (KL grade)		
1	1HR	1KPClRF	36.5	63.5
2	3HR	3KPClRF	22.5	77.5
3	1H'R	1KPClRFc	19.5	80.5
4	3H'R	3KPClRFc	15.0	85.0

The calculation is as follows :

$$\text{wt gain/g} = \frac{W_{AS} - W_{DS}}{W_{DS}}, \quad \text{wt loss/l} = \frac{W_{BS}(1-q)-W_{DS}}{V_{BS} \times 10^{-3}}$$

where, W_{AS}=wt after sorption, W_{DS} = wt of dried sample, W_{BS}=wt before sorption, V_{BS}= vol before sorption and q= moisture content per g.

The observations for the resins presented in II.3 are presented in tables II.9, II.10 and II.11.

4(d) Cu(II) ion uptake

0.2 g (exactly weighed) H-form of the resin was taken in a dry 250 ml glass stoppered bottle. To the sample in the bottle were added 100 ml of standardized (pH~10) ammonical copper sulphate solution. The mixture was kept for 48 hours with occasional shaking. 25 ml aliquots of the supernatant liquid were titrated against standard sodium thiosulphate solution. Blank reading for 25 ml solution was also taken.

The copper ion uptake is calculated as follows :

$$\frac{(T_o - T_e) \times 4 \times \text{molarity of sodium thiosulphate solution}}{\text{Wt of sample} \times \left(\frac{\%\ \text{solid}}{100}\right)}$$

$$= \frac{\text{millimoles of Cu-exchange}}{\text{g of dried H-form resin}}$$

Where, T_o= Titration reading for 25 ml solution without resin

T_e= Titration reading for 25 ml solution with resin (at equilibrium)

The results are presented in tables II.12.

Table II.9(a)

No	Expt	Product	Sample in water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	19AR	19KPFR	0.30	0.00
2	25AR	25KPFR	0.52	0.00
3	$19A(R)_{0.5}$	19KPFR'	1.11	0.00
4	$25A(R)_{0.5}$	25KPFR'	1.25	0.00
5	19A'R	19KPFRc	0.42	0.00
6	25A'R	25KPFRc	0.84	0.00
7	$19A'(R)_{0.5}$	19KPFR'c	1.16	0.00
8	$25A'(R)_{0.5}$	25KPFR'c	1.60	0.00

Table II.9(b)

No	Expt	Product	Sample in water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	5CR	5KPFQR	0.46	0.28
2	6CR	6KPFQR	0.30	0.40
3	7CR	7KPFQR	0.27	0.80
4	5C'R	5KPFQRc	0.87	0.66
5	6C'R	6KPFQRc	0.60	0.81
6	7C'R	7KPFQRc	0.59	1.04

Table II.9(c)

No	Expt	Product	Sample in water Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	3ER	3KPERF	0.61	0.32
2	5ER	5KPERF	0.61	0.32
3	3E'R	3KPERFc	0.71	0.10
4	5E'R	5KPERFc	0.73	0.10

Table II.9(d)

No	Expt	Product	Sample in water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	1HR	1KPC1RF	0.50	0.00
2	3HR	3KPC1RF	0.63	0.00
3	1H'R	1KPC1RFc	0.88	0.00
4	3H'R	3KPC1RFc	1.54	0.20

Table II.10(a)

No	Expt	Product	Sample in 1% NaCl solution	
			Wt gain/g (g/g)	Wt loss/l (g/l)
			PVA (KL grade)	
1	19AR	19KPFR	0.28	0.00
2	25AR	25KPFR	0.40	0.00
3	19A'R	19KPFRc	0.41	0.00
4	25A'R	25KPFRc	0.80	0.00

Table II.10(b)

No	Expt	Product	Sample in 1% NaCl solution	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	5CR	5KPFQR	0.27	0.00
2	6CR	6KPFQR	0.16	0.00
3	7CR	7KPFQR	0.16	0.00
4	5C'R	5KPFQRc	0.22	0.00
5	6C'R	6KPFQRc	0.15	0.00
6	7C'R	7KPFQRc	0.44	0.00

Table II.10(c)

No	Expt	Product	Sample in 1% NaCl solution	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	3ER	3KPERF	0.27	0.00
2	5ER	5KPERF	0.39	0.00
3	3E'R	3KPERFc	0.43	0.00
4	5E'R	5KPERFc	0.60	0.00

Table II.10(d)

No	Expt	Product	Sample in 1% NaCl solution	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	1HR	1KPClRF	0.28	0.00
2	3HR	3KPClRF	0.32	0.00
3	1H'R	1KPClRFc	0.50	0.00
4	3H'R	3KPClRFc	0.80	0.00

Table II.11(a)

No	Expt	Product	Sample in 10% NaCl solution	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	19AR	19KPFR	0.04	0.00
2	25AR	25KPFR	0.19	0.00
3	19A'R	19KPFRc	0.14	0.00
4	25A'R	25KPFRc	0.77	0.00

Table II.11(b)

No.	Expt	Product	Sample in 10% NaCl solution	
			Wt gain/g (g/g)	Wt loss/l (g/l)
		PVA (KL grade)		
1	5CR	5KPFQR	0.03	0.00
2	6CR	6KPFQR	0.03	0.00
3	7CR	7KPFQR	0.02	0.00
4	5C'R	5KPFQRc	0.11	0.00
5	6C'R	6KPFQRc	0.04	0.00
6	7C'R	7KPFQRc	0.39	0.00

Table II.11(c)

No	Expt	Product	Sample in 10% NaCl solution	
			Wt gain/g (g/g)	Wt loss/1 (g/1)
		PVA (KL grade)		
1	3ER	3KPERF	0.08	0.00
2	5ER	5KPERF	0.09	0.00
3	3E'R	3KPERFc	0.30	0.00
4	5E'R	5KPERFc	0.50	0.00

Table II.12(b)

pH of Cu(II) solution ~ 10

No	Expt	Product	Amount of Cu(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	5CR	5KPFQR	11.15	0.35
2	6CR	6KPFQR	11.70	0.21
3	7CR	7KPFQR	11.51	0.26
4	5C'R	5KPFQRc	11.13	0.51
5	6C'R	6KPFQRc	11.23	0.40
6	7C'R	7KPFQRc	11.13	0.51

Table II.12(c)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	3ER	3KPERF	12.25	0.56
2	5ER	5KPERF	11.08	0.56
3	3E'R	3KPERFc	11.34	0.79
4	5E'R	5KPERFc	11.03	1.12

Table II.12(d)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	1HR	1KPClRF	12.06	0.43
2	3HR	3KPClRF	10.98	0.35
3	1H'R	1KPClRFc	11.73	0.76
4	3H'R	3KPClRFc	10.80	0.97

4(e) Ni(II) ion uptake

0.2 g (exactly weighed) H-form of the resin was taken in dry 250 ml glass stoppered bottle. To the sample in the bottle were added 100 ml of standardized (pH$\sim$10) ammonical nickel sulphate solution. The mixture was kept for 48 hours with occasional shaking. 25 ml aliquots of the supernatant liquid were titrated against standard M/20 (or M/10) EDTA solution. Blank reading for 25 ml solution was also taken.

The nickel ion uptake is calculated as follows :

$$\frac{(T_o - T_e) \times 4 \times \text{molarity of EDTA}}{\text{Wt of sample} \times \frac{(\%\ \text{solid})}{100}} = \frac{\text{Millimoles of Ni-exchange}}{\text{g of dried H-form resin}}$$

Where, T_o = Titration reading for 25 ml solution without resin

T_e = Titration reading for 25 ml solution with resin (at equilibrium)

The results are presented in table II.13.

4(f) Zn(II) ion uptake

0.2 g (exactly weighed) H-form of the resin was taken in a dry 250 ml glass stoppered bottle. To the sample in the bottle were added 100 ml of standardized (pH$\sim$10) ammonical zinc sulphate solution. The mixture was kept for 48 hours with occasional shaking. 25 ml aliquots of the supernatant liquid were titrated against standard EDTA solution. Blank

Table II.13(a)

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
pH of Ni(II) solution ~10				
1	19AR	19KPFR	18.87	0.89
2	25AR	25KPFR	18.78	0.98
3	19A'R	19KPFRc	21.12	0.63
4	25A'R	25KPFRc	20.05	0.69

Table II.13(a) (contd.)

1	2	3	4	5
pH of Ni(II) solution ~10				
5	$19A(R)_{0.5}$	19KPFR'	47.71	1.66
6	$25A(R)_{0.5}$	25KPFR'	49.26	0.63
7	$19A'(R)_{0.5}$	19KPFR'c	45.21	0.42
8	$25A'(R)_{0.5}$	25KPFR'c	46.38	0.21

<u>Table II.13(b)</u>

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
			<u>PVA (KL grade)</u>	
1	5CR	5KPFQR	19.76	0.67
2	6CR	6KPFQR	20.63	0.52
3	7CR	7KPFQR	20.09	0.62
4	5C'R	5KPFQRc	19.82	0.77
5	6C'R	6KPFQRc	19.99	0.51
6	7C'R	7KPFQRc	19.82	0.68

Table II.13(c)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (mmole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	3ER	3KPERF	21.92	0.84
2	5ER	5KPERF	19.73	0.94
3	3E'R	3KPERFc	20.86	0.71
4	5E'R	5KPERFc	20.77	0.74

Table II.13(d)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m·mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	1HR	1KPC1RF	21.19	1.00
2	3HR	3KPC1RF	19.21	1.30
3	1H'R	1KPC1RFc	21.10	0.91
4	3H'R	3KPC1RFc	19.96	0.97

reading for 25 ml solution was also taken.

The zinc ion uptake is calculated as follows:

$$\frac{(T_o - T_e) \times 4 \times \text{molarity of EDTA}}{\text{Wt of sample} \times \frac{(\%\ \text{solid})}{100}}$$

$$= \frac{\text{Millimoles of Zn-exchange}}{\text{g of dried H-form resin}}$$

Where, T_o = Titration reading for 25 ml solution without resin

T_e = Titration reading for 25 ml solution with resin (at equilibrium)

The results are presented in table II.14.

II.5 CHELATING POLYMERS (BIS-PHENOL-A RESINS)

5(a) Synthesis of chelating polymers using bisphenol-A, formaldehyde and phenol derivatives under acidic condition

Bisphenol-A dissolved in sodiumhydroxide solution was taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde and phenol derivative (salicyl aldehyde or salicylic acid) dissolved in requisite quantity of sodium hydroxide solution were added to it. The reaction mixture after adding hydrochloric acid was heated on sand bath at 100-110°C with occasional shaking. The gel obtained was removed, cured at room temperature for two weeks, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh

Table II.14(a)

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
pH of Zn(II) solution ~ 10				
1	19AR	19KPFR	25.63	0.77
2	25AR	25KPFR	25.72	0.68
3	19A'R	19KPFRc	28.55	0.75
4	25A'R	25KPFRc	27.12	0.82
5	$19A(R)_{0.5}$	19KPFR'	48.05	0.58
6	$25A(R)_{0.5}$	25KPFR'	48.56	0.59
7	$19A'(R)_{0.5}$	19KPFR'c	48.50	1.62
8	$25A'(R)_{0.5}$	25KPFR'c	48.81	1.86

Table II.14(b)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	5CR	5KPFQR	27.80	0.50
2	6CR	6KPFQR	27.95	0.31
3	7CR	7KPFQR	27.87	0.73
4	5C'R	5KPFQRc	27.21	0.40
5	6C'R	6KPFQRc	27.11	0.51
6	7C'R	7KPFQRc	26.80	0.81

Table ii.14(c)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	3ER	3KPERF	29.63	0.78
2	5ER	5KPERF	27.11	0.51
3	3E'R	3KPERFc	28.52	0.42
4	5E'R	5KPERFc	29.31	0.64

Table II.14(d)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
			PVA (KL grade)	
1	1HR	1KPClRF	28.90	0.79
2	3HR	3KPClRF	26.30	0.69
3	1H'R	1KPClRFc	28.79	0.87
4	3H'R	3KPClRFc	26.22	0.72

size and used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(a).

5(b) Synthesis of chelating polymers using bisphenol-A, formaldehyde and phenol or amine derivative under alkaline condition

Bisphenol-A dissolved in sodium hydroxide solution was taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde alone or containing salicyl aldehyde (or 4-amino benzoic acid) or starch and 4-hydroxy benzoic acid (or 1-amino-2-naphthol-4-sulphonic acid) dissolved in sodium hydroxide solution was added to the mixture. The reaction mixture was heated on sand bath at 100-110°C with occasional shaking. The gel obtained was removed and cured at room temperature for two weeks, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(b).

5(c) Synthesis of chelating polymers using bisphenol-A, formaldehyde, phenol or amine derivative and resorcinol under acidic condition

Bisphenol-A dissolved in sodium hydroxide solution was taken in 250 ml round bottom flask fitted with reflux

Table II.15(a)

Wt of bisphenol-A : 3 g

Vol of F : 4.4 ml

Vol of HCl : 2 ml

No	Expt	Product	Wt or vol of phenol derivative (g) or (ml)	Time of reaction (min)	Wt of product (g)
1	3aF	BFSha	2.8 (Sh)	90	3.0
2	4aF	BFSda	3.6 (Sd)	50	2.5

Table II.15(b)

Wt of bisphenol-A : 3 g

No	Expt	Product	Wt of starch (c) (g)	Vol of F (ml)	Wt or vol of phenol or amine derivative (g) or (ml)	Wt of NaOH (g)	Time of reaction (min)	Wt of product (g)
1	1bF	BF	-	6.6	-	1	180	3.8
2	3bF	BFSh	-	8.8	2.8 (Sh)	1	240	6.4
3	6bF	BFAm	-	8.8	3.6 (Am)	1	240	5.6
4	5bSF	BFAh	3	8.8	3.6 (Ah)	1	1020	6.5
5	7bSF	BFAn	3	8.8	1.6 (An)	2	510	6.6

condenser. Formaldehyde alone or containing 8-hydroxy quinoline (or 4-amino benzoic acid), or starch and 8-hydroxy quinoline (or salicyl aldehyde or salicylic acid or 4-hydroxy benzoic acid or 4-amino benzoic acid or 1-amino-2-naphthol-4-sulphonic acid) dissolved in requisite quantity of sodium hydroxide solution was added to the mixture. The reaction mixture after adding hydrochloric acid was heated on sand bath at 100-110°C with occasional shaking. Soft gel was formed. It was dissolved in sodium hydroxide solution. Resorcinol and additional amount of formaldehyde (with or without starch) were added to the above mixture and heating at 100-110°C was continued further. The gel was obtained. It was cured at room temperature for two weeks, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(c).

5(d) Synthesis of chelating polymers using bisphenol-A, formaldehyde, phenol derivative and resorcinol under alkaline condition

Bisphenol-A dissolved in sodium hydroxide solution was taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde and salicylic acid dissolved in requisite quantity of sodium hydroxide solution were added to the mixture. The reaction mixture was heated on sand bath at 100-110°C with occasional shaking. Soft gel was

Table II.15(c)

Wt of bisphenol-A : 3 g

Wt of resorcinol (R) : 3 g

Additional vol of F : 5 ml

No	Expt	Product	Wt of starch (c) (g)	Vol of F (ml)	Wt or vol of phenol or amine derivative (g) or (ml)	Vol of HCl (ml)	Time of reaction (i) (min)	Wt of starch (c) (g)	Time of reaction (ii) (min)	Wt of product (g)
1	2	3	4	5	6	7	8	9	10	11
1	1aFR	BFRF	-	2.2	-	2	50	-	30	4.3
2	2aFR	BFQRF	-	4.4	3.8 (Q)	2	375	-	30	2.7
3	6aFR	BFAmRF	-	4.4	3.6 (Am)	4	50	-	30	4.7
4	2aSFR	BFQRFc	3	4.5	3.8 (Q)	2	240	3	240	5.7

Table II.15(c) (contd.)

1	2	3	4	5	6	7	8	9	10	11
5	3aSFR	BFShRFc	3	4.5	2.8 (Sh)	3	180	3	120	6.8
6	4aSFR	BFSdRFc	3	4.5	3.6 (Sd)	3	180	3	60	7.6
7	5aSFR	BFAhRFc	3	4.5	3.6 (Ah)	4	150	3	60	4.4
8	6aSFR	BFAmRFc	3	4.5	3.6 (Am)	5	150	3	90	5.5
9	7aSFR	BFAnRFc	3	4.5	1.6 (An)	4	240	3	150	6.1

formed. It was dissolved in sodium hydroxide solution. Then resorcinol dissolved in sodium hydroxide solution and additional amount of formaldehyde were added to the above mass and heating at 100-110°C was continued further. The gel was obtained. It was cured at room temperature for two weeks, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(d).

5(e) Synthesis of chelating polymer using bisphenol-A, formaldehyde, phenol derivative and epichlorhydrin under acidic condition

Bisphenol-A dissolved in sodium hydroxide solution was taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde, salicyl aldehyde and hydrochloric acid were added to the mixture. The reaction mixture was heated on sand bath at 100-110°C with occasional shaking. Epichlorhydrin and sodium hydroxide solution were added to the above mixture dropwise and with continuous shaking, and heating at 100-110°C was continued further. The gel obtained was cured at room temperature for two weeks, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(e).

Table II.15(d)

Wt of bisphenol-A : 3 g

Wt of resorcinol (R) : 1 g

Additional vol of F: 5 ml

No	Expt	Product	Vol of F (ml)	Wt of phenol derivative (g)	Wt of NaOH (g)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	4bFR	BFSdRF	8.8	3.6 (Sd)	1	1080	30	4.8

Table II.15(e)

Wt of bisphenol-A : 3 g

Vol of F : 4.4 ml

No	Expt	Product	Vol of phenol derivative (ml)	Vol of HCl (ml)	Time of reaction (i) (min)	Vol of epichlorhydrin (e) (ml)	Wt of NaOH (g)	Time of reaction (ii) (min)	Wt of product (g)
1	3aFE	BFShe	2.8 (Sh)	2	30	1	1	90	4.6

5(f) Synthesis of chelating polymers using bisphenol-A, formaldehyde, phenol or amine derivative, epichlorhydrin and resorcinol under acidic condition

Bisphenol-A dissolved in sodium hydroxide solution was taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde and 8-hydroxy quinoline (or salicylic acid or 4-amino benzoic acid) dissolved in requisite quantity of sodium hydroxide solution were added to the mixture. The reaction mixture after adding hydrochloric acid was heated on sand bath at 100-110°C with occasional shaking. Then epichlorhydrin and sodium hydroxide solution were added to the above mixture dropwise and with continuous shaking and heating at 100-110°C was continued further. The gel obtained was removed and dissolved in sodium hydroxide solution. Resorcinol dissolved in sodium hydroxide solution and additional amount of formaldehyde were added to the above mixture and heating at 100-110°C was continued further. The gel was obtained. It was cured at room temperature for two weeks, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(f).

Table II.15(f)

Wt of bisphenol-A : 3 g

Vol of F : 4.4 ml

Vol of epichlorhydrin (e) : 1 ml

Wt of NaOH : 1 g

Wt of resorcinol (R) : 1 g

Additional vol of F : 5 ml

No	Expt	Product	Wt of phenol or amine derivative (g)	Vol of HCl (ml)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Time of reaction (iii) (min)	Wt of product (g)
1	2aFER	BFQeRF	3.8 (Q)	3	90	90	30	1.9
2	4aFER	BFSdeRF	3.6 (Sd)	2	30	60	30	4.4
3	6aFER	BFAmeRF	3.6 (Am)	4	10	30	30	3.2

5(g) Synthesis of chelating polymer using bisphenol-A, formaldehyde, phenol derivative and epichlorhydrin in non-aqueous solvent under alkaline condition

Bisphenol-A dissolved in toluene was taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde alone or containing 8-hydroxy quinoline (or salicyl aldehyde or 1-amino-2-naphthol-4-sulphonic acid) and sodium hydroxide pellets were added to the mixture. The reaction mixture was heated on water bath at 80-90°C with occasional shaking. Epichlorhydrin was added dropwise and with continuous shaking to the above mixture, and heating at 80-90°C was continued further. The gel obtained was removed, cured on steambath at 90-100°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(g).

5(h) Synthesis of chelating polymers using bisphenol-A, formaldehyde, phenol derivative, epichlorhydrin and diethylene triamine in non-aqueous solvent

Bisphenol-A dissolved in toluene was taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde alone or containing 8-hydroxy quinoline (or salicyl aldehyde or salicylic acid) and diethylene triamine were

Table II.15(g)

Wt of bisphenol-A : 3 g

Vol of F : 10 ml

Wt of NaOH : 0.5 g

Vol of epichlorhydrin (e) : 1 ml

No	Expt	Product	Wt or vol of phenol drivative (g) or (ml)	Vol of toluene (ml)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	1T	TBFe	-	10	120	60	5.1
2	2T	TBFQe	3.8 (Q)	20	120	60	5.8
3	3T	TBFShe	2.8 (Sh)	10	120	240	5.4
4	7T	TBFAne	1.6 (An)	10	60	120	5.0

added to the mixture. The reaction mixture was heated on water bath at 80-90°C with occasional shaking. Then epichlorhydrin was added dropwise and with continuous shaking to the above mixture, and heating at 80-90°C was continued further. The gel obtained was removed, cured on steam bath at 90-100°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35-100 BSS mesh size and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.15(h).

The solubility of all these products (II.5) have been studied in different solvents and the data are presented in table II.16.

H-form of the resin having 35-100 BSS mesh size was used for studying water content of the resin, % sorption of water by the resin, Cu(II) ion uptake, Ni(II) ion uptake and Zn(II) ion uptake. The data are presented in tables II.17, II.18, II.19, II.20 and II.21 respectively.

II.6 CHELATING POLYMERS (ACRYLIC AND XANTHATE RESINS)

6(a) Synthesis of chelating polymers using acrylamide, formaldehyde and amine derivatives

Acrylamide dissolved in water and potassium persulphate solution were taken in 250 ml round bottom flask fitted with reflux condenser. The reaction mixture was

Table II.15(h)

Wt of bisphenol-A : 3 g
Vol of F : 10 ml
Vol of toluene : 10 ml
Vol of diethylene triamine (D) : 1 ml
Vol of epichlorhydrin (e) : 1 ml

No	Expt	Product	Wt or vol of phenol derivative (g) or (ml)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	1TD	TBFDe	-	60	240	5.0
2	2TD	TBFQDe	3.8 (Q)	20	180	9.6
3	3TD	TBFShDe	2.8 (Sh)	15	180	6.9
4	4TD	TBFSdDe	3.6 (Sd)	30	150	5.1

Table II.16

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	2	3	4	5	6	7	8	9	10
				(a)					
1	3aF	BFSha	brown	i	i	i	i	i	i
				(b)					
2	1bF	BF	brown	i	i	i	i	i	i
3	3bF	BFSh	orange	i	i	i	i	i	i
4	6bF	BFAm	red	i	i	i	i	i	i
5	5bSF	BFAh	orange	i	i	i	i	i	i
6	7bSF	BFAn	red	i	i	i	i	i	i

Table II.16 (contd)

1	2	3	4	5	6	7	8	9	10
					(c)				
7	1aFR	BFRF	brown	i	i	i	i	i	i
8	2aFR	BFQRF	red	i	i	i	i	i	i
9	6aFR	BFAmRF	red	i	i	i	i	i	i
10	2aSFR	BFQRFc	red	i	i	i	i	i	i
11	3aSFR	BFShRFc	orange	i	i	i	i	i	i
12	4aSFR	BFSdRFc	brown	i	i	i	i	i	i
13	5aSFR	BFAhRFc	red	i	i	i	i	i	i
14	6aSFR	BFAmRFc	red	i	i	i	i	i	i
15	7aSFR	BFAnRFc	brown	i	i	i	i	i	i

Table II.16 (contd)

1	2	3	4	5	6	7	8	9	10
					(d)				
16	4bFR	BFSdRF	red	i	i	i	i	i	i
					(e)				
17	3aFE	BFShe	brown	i	i	i	i	i	i
					(f)				
18	2aFER	BFQeRF	red	i	i	i	i	i	i
19	4aFER	BFSdeRF	red	i	i	i	i	i	i
20	6aFER	BFAmeRF	red	i	i	i	i	i	i
					(g)				
21	1T	TBFe	yellow	i	i	i	i	i	i

Table II.16 (contd)

1	2	3	4	5	6	7	8	9	10
					(g)				
22	2T	TBFQe	yellow	i	i	i	i	i	i
23	3T	TBFShe	yellow	i	i	i	i	i	i
24	7T	TBFAne	brown	i	i	i	i	i	i
					(h)				
25	1TD	TBFDe	yellow	i	i	i	i	i	i
26	2TD	TBFQDe	red	i	i	i	i	i	i
27	3TD	TBFShDe	yellow	i	i	i	i	i	i
28	4TD	TBFSdDe	brown	i	i	i	i	i	i

Table II.17(a)

No	Expt	Product	Water content %	Solid content %
1	3aF	BFSha	4.5	95.5
2	4aF	BFSda	2.5	97.5

Table II.17(b)

No	Expt	Product	Water content %	Solid content %
1	1bF	BF	5.0	95.0
2	3bF	BFSh	2.5	97.5
3	6bF	BFAm	5.5	94.5
4	5bSF	BFAh	5.0	95.0
5	7bSF	BFAn	7.0	93.0

Table II.17(c)

No	Expt	Product	Water contnet %	Solid content %
1	1aFR	BFRF	6.0	94.0
2	2aFR	BFQRF	8.5	91.5
3	6aFR	BFAmRF	9.5	90.5
4	2aSFR	BFQRFc	6.0	94.0
5	3aSFR	BFShRFc	7.0	93.0
6	4aSFR	BFSdRFc	6.5	93.5
7	5aSFR	BFAhRFc	6.0	94.0
8	6aSFR	BFAmRFc	6.0	94.0
9	7aSFR	BFAnRFc	6.0	94.0

Table II.17(d)

No	Expt	Product	Water content %	Solid content %
1	4bFR	BFSdRF	9.0	91.0

Table II.17(e)

No	Expt	Product	Water content %	Solid content %
1	3aFE	BFShe	4.0	96.0

Table II.17(f)

No	Expt	Product	Water content %	Solid content %
1	2aFER	BFQeRF	10.5	89.5
2	4aFER	BFSdeRF	6.0	94.0
3	6aFER	BFAmeRF	9.0	91.0

Table II.17(g)

No	Expt	Product	Water content %	Solid content %
1	1T	TBFe	10.0	90.0
2	2T	TBFQe	9.0	91.0
3	3T	TBFShe	6.0	94.0
4	7T	TBFAne	6.5	93.5

Table II.17(h)

No	Expt	Product	Water content %	Solid content %
1	1TD	TBFDe	6.5	93.5
2	2TD	TBFQDe	12.0	88.0
3	3TD	TBFShDe	7.0	93.0
4	4TD	TBFSdDe	8.5	91.5

Table II.18(a)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/1 (g/1)
1	3aF	BFSha	0.15	0.00
2	4aF	BFSda	0.33	0.00

Table II.18(b)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1bF	BF	0.18	0.00
2	3bF	BFSh	0.18	0.00
3	6bF	BFAm	0.13	0.00
4	5bSF	BFAh	0.40	0.00
5	7bSF	BFAm	0.25	0.00

Table II.18(c)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1aFr	BFRF	0.45	0.00
2	2aFR	BFQRF	0.18	0.00
3	6aFR	BFAmRF	0.18	0.00
4	2aSFR	BFQRFc	0.31	0.00
5	3aSFR	BFShRFc	0.34	0.00

Table II.18(c) (contd.)

1	2	3	4	5
6	4aSFR	BFSdRFc	0.29	0.00
7	5aSFR	BFAhRFc	0.35	0.00
8	6aSFR	BFAmRFc	0.31	0.00
9	7aSFR	BFAnRFc	0.41	0.00

Table II.18(d)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	4bFR	BFSdRF	0.34	0.00

Table II.18(e)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	3aFE	BFShe	0.14	0.00

Table II.18(f)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	2aFER	BFQeRF	0.26	0.00
2	4aFER	BFSdeRF	0.27	0.00
3	6aFER	BFAmeRF	0.47	0.00

Table II.18(g)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1T	TBFe	0.25	0.00
2	2T	TBFQe	1.61	0.00
3	3T	TBFShe	0.29	0.00
4	7T	TBFAne	0.31	0.00

Table II.18(h)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1TD	TBFDe	0.18	0.00
2	2TD	TBFQDe	0.53	0.10
3	3TD	TBFShDe	0.34	0.00
4	4TD	TBFSdDe	0.26	0.00

Table II.19(a)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	3aF	BFSha	25.83	0.31
2	4aF	BFSda	24.08	1.53

Table II.19(b)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1bF	BF	26.21	0.21
2	3bF	BFSh	25.31	0.31
3	6bF	BFAm	25.16	1.26
4	5bSF	BFAh	25.26	1.16
5	7bSF	BFAn	25.81	1.18

Table II.19(c)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1aFR	BFRF	25.53	1.17
2	2aFR	BFQRF	25.87	1.41
3	6aFR	BFAmRF	26.04	1.54
4	2aSFR	BFQRFc	25.74	0.85

Table II.19(c) (contd.)

1	2	3	4	5
5	3aSFR	BFShRFc	26.02	0.86
6	4aSFR	BFSdRFc	25.53	1.06
7	5aSFR	BFAhRFc	25.64	0.96
8	6aSFR	BFAmRFc	25.53	1.06
9	7aSFR	BFAnRFc	25.64	0.96

Table II.19(d)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	4bFR	BFSdRF	26.04	1.54

Table II.19(e)

pH of Cu(II) solution ~ 10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	3aFE	BFShe	25.83	0.31

Table II.19(f)

pH of Cu(II) solution ~ 10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	2aFER	BFQeRF	26.78	1.11
2	4aFER	BFSdeRF	24.89	1.81
3	6aFER	BFAmeRF	25.23	1.65

Table II.19(g)

pH of Cu(II) solution ~ 10

No	Expt	Product	Amount of Cu(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1T	TBFe	30.00	0.11
2	2T	TBFQe	29.67	0.11
3	3T	TBFShe	29.72	0.11
4	7T	TBFAne	28.19	0.64

Table II.19(h)

pH of Cu(II) solution ~ 10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1TD	TBFDe	28.72	0.11
2	2TD	TBFQDe	28.57	0.23
3	3TD	TBFShDe	28.92	0.22
4	4TD	TBFSdDe	29.13	0.33

Table II.20(a)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	3aF	BFSha	45.6	0.40
2	4aF	BFSda	43.10	1.96

Table II.20(b)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1bF	BF	46.08	0.40
2	3bF	BFSh	44.67	0.39
3	6bF	BFAm	45.07	1.41
4	5bSF	BFAh	45.07	1.41
5	7bSF	BFAn	46.04	1.45

Table II.20(c)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1aFR	BFRF	44.94	2.04
2	2aFR	BFQRF	46.54	1.46
3	6aFR	BFAmRF	46.42	2.11
4	2aSFR	BFQRFc	51.68	1.43

Table II.20(c) (contd.)

1	2	3	4	5
5	3aSFR	BFShRFc	52.44	1.24
6	4aSFR	BFSdRFc	51.68	1.43
7	5aSFR	BFAhRFc	51.68	1.43
8	6aSFR	BFAmRFc	51.68	1.43
9	7aSFR	BFAnRFc	51.88	1.23

Table II.20(d)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	4bFR	BFSdRF	45.78	2.74

Table II.20(e)

ph of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	3aFE	BFShe	45.60	0.40

Table II.20(f)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	2aFER	BFQeRF	46.93	2.13
2	4aFER	BFSdeRF	44.94	2.04
3	6aFER	BFAmeRF	46.42	2.11

Table II.20(g)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1T	TBFe	55.78	0.22
2	2T	TBFQe	54.95	0.44
3	3T	TBFShe	53.40	0.21
4	7T	TBFAne	52.55	1.06

Table II.20(h)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1TD	TBFDe	53.40	0.21
2	2TD	TBFQDe	57.27	0.00
3	3TD	TBFShDe	54.19	0.00
4	4TD	TBFSdDe	54.56	0.22

Table II.21(a)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	3aF	BFSha	47.69	0.40
2	4aF	BFSda	45.53	1.58

Table II.21(b)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1bF	BF	48.19	0.41
2	3bF	BFSh	46.72	0.40
3	6bF	BFAm	46.56	2.04
4	5bSF	BFAh	46.97	1.63
5	7bSF	BFAn	47.98	1.67

Table II.21(c)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1aFR	BFRF	47.06	2.06
2	2aFR	BFQRF	48.08	2.11
3	6aFR	BFAmRF	48.39	2.35
4	2aSFR	BFQRFc	49.94	1.65

Table II.21(c) (contd.)

1	2	3	4	5
5	3aSFR	BFShRFc	50.69	1.46
6	4aSFR	BFSdRFc	49.94	1.65
7	5aSFR	BFAhRFc	49.94	1.65
8	6aSFR	BFAmRFc	49.74	1.86
9	7aSFR	BFAnRFc	49.94	1.65

Table II.21(d)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	4bFR	BFSdRF	48.61	2.13

Table II.21(e)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	3aFE	BFShe	47.49	0.61

Table II.21(f)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	2aFER	BFQeRF	49.58	1.72
2	4aFER	BFSdeRF	46.85	2.27
3	6aFER	BFAmeRF	48.39	2.35

Table II.21(g)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1T	TBFe	54.00	0.22
2	2T	TBFQe	53.19	0.44
3	3T	TBFShe	51.70	0.21
4	7T	TBFAne	50.85	1.06

Table II.21(h)

pH of Zn(II) solution $\sim$ 10

No	Expt	Product	Amount of Zn(II) (m·mole/g) at equilibrium	
			in solution	in resin phase
1	1TD	TBFDe	51.70	0.21
2	2TD	TBFQDe	55.22	0.23
3	3TD	TBFShDe	52.26	0.22
4	4TD	TBFSdDe	52.61	0.43

heated on water bath at 50 - 60°C with occasional shaking for definite time. Formaldehyde and 20% hydrochloric acid solutions were added to the above mixture and heating at 50 - 60°C was continued further for definite time. Then glycine (or anthranilic acid or 4-aminobenzoic acid or m-aminophenol) dissolved in sodiumhydroxide solution and sodiumhydroxide solution were added to the mixture, and heating at 50 - 60°C was continued still further. The gel obtained was removed, cured at 90 -100°C, washed with water, acid, alkali, acid, water and alcohol respectively, dried, ground to 35 - 100 BSS mesh size and then used for investigations. The amounts of reactants used, time of reaction, time of curing, yield of product, etc, are given in the table II.22(a).

6(b) Synthesis of chelating polymer using m-aminophenol and formaldehyde

m-Aminophenol dissolved in sodium hydroxide solution was taken in 250 ml round bottom flask fitted with reflux condenser. Carbon disulphide and sodiumacetate solution were added to the mixture. The reaction mixture was heated on water bath at 50 - 60°C with occasional shaking for definite time. Then formaldehyde and sodiumhydroxide solutions were added to the above mixture and heating at 50 - 60°C was continued further. The gel obtained was removed, cured at 90 - 100°C, washed with water, acid, alkali, acid, water and alcohol respectively, dried,

Table II.22(a)

Wt of acrylamide : 3 g

Vol of F : 6 ml

Wt of $K_2S_2O_8$: 0.03 g

Time of curing : 24 hrs

No	Expt	Product	Time of reaction (min)	Vol of 20% HCl solution (ml)	Time of reaction (min)	Wt of amine derivative (g)	Wt of NaOH pellet (g)	Time of reaction (min)	Wt of product (g)
1	9a	AFGl	120	2	60	1.5 (Gl)	0.5	120	4.2
2	9b	AFAd	120	2	60	3.0 (Ad)	0.5	120	6.7
3	9c	AFAm	120	2	60	3.0 (Am)	0.5	120	5.9
4	9d	AFAp	120	2	60	2.5 (Ap)	0.5	120	8.2

ground to 35 - 100 BSS mesh size, and then used for investigations. The amounts of reactants used, time of reaction, time of curing, yield of product, etc, are given in the table II.22(b).

The solubility of these products have been studied in different solvents and the data are presented in table II.23.

H-form of the resin having 35 - 100 BSS mesh size was used for studying water content of the resin, % sorption of water by the resin, Cu(II) ion uptake, Ni(II) ion uptake and Zn(II) ion uptake. The data are presented in tables II.24, II.25, II.26, II.27 and II.28 respectively.

II.7 CHELATING MEMBRANES

7(a) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde and resorcinol

Polyvinyl alcohol (KL grade) and glycerine (or polyethylene glycol) were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde in presence or absence of starch solution and sodium carbonate solution were added to the mass. The reaction mixture was heated on water bath at 70 - 80°C with occasional shaking for definite time. Then resorcinol and additional amount of formaldehyde were added to the above mixture and heating at 70-80°C was continued further. The gel obtained was pressed between two glass plates applying mild pressure and kept

Table II.22(b)

Wt of m-amino phenol : 5 g
Vol of F : 7 ml
Time of curing : 24 hrs

No	Expt	Product	Vol of carbon disulphide (ml)	Wt of sodium acetate (g)	Time of reaction (min)	Wt of NaOH pellet (g)	Time of reaction (min)	Wt of product (g)
1	27	ApFX	3	1	90	0.5	15	8.5

Table II.23

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	9a	AFGl	white	i	i	i	i	i	i
2	9b	AFAd	brown	i	i	i	i	i	i
3	9c	AFAm	yellow	i	i	i	i	i	i
4	9d	AFAp	brown	i	i	i	i	i	i
5	27	ApFX	black	i	i	i	i	i	i

Table II.24

No	Expt	Product	Water content %	Solid content %
1	9a	AFGl	10.0	90.0
2	9b	AFAd	9.0	91.0
3	9c	AFAm	7.5	92.5
4	9d	AFAp	10.0	90.0
5	27	ApFX	9.0	91.0

Table II.25

No.	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	9a	AFGl	2.65	0.00
2	9b	AFAd	0.30	0.00
3	9c	AFAm	0.49	0.00
4	9d	AFAp	0.57	0.00
5	27	ApEX	0.13	0.00

Table II.26

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	9a	AFGl	27.11	0.78
2	9b	AFAd	26.81	0.77
3	9c	AFAm	26.13	0.86
4	9d	AFAp	26.89	1.00
5	27	ApFX	26.26	1.32

Table II.27

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	9a	AFGl	47.33	0.67
2	9b	AFAd	46.81	0.66
3	9c	AFAm	45.81	0.65
4	9d	AFAp	47.11	0.89
5	27	ApFX	47.03	0.44

Table II.28

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	9a	AFGl	53.11	0.89
2	9b	AFAd	52.31	1.10
3	9c	AFAm	51.40	0.86
4	9d	AFAp	52.67	1.33
5	27	ApFX	51.87	1.54

overnight. The membrane formed was cured (i) by separating it from glass plates and keeping it on steam bath (SB) at about 100°C for 24 hours or (ii) by dipping the glass plates with the membrane in water bath (WB) at 80-90°C for 24 hours. The membrane was washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc. are given in the table II.29(a).

7(b) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, resorcinol and 8-hydroxy quinoline

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde in presence or absence of starch solution and sodium carbonate solution were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then resorcinol and additional amount of formaldehyde were added to the above mixture followed by the addition of 8-hydroxy quinoline dissolved in hydrochloric acid and heating at 70-80°C was continued further. The gel obtained was pressed between two glass plates applying mild pressure and kept overnight. The membrane formed was cured (i) by separating it from glass-plates and keeping it on steam bath (SB) at about 100°C for 24 hours or (ii) by dipping the glass-plates with

Table II.29(a)

Wt of PVA (KL grade) : 3 g

Vol of F : 5 ml

Vol of G or Pg : 10 ml

Wt of resorcinol (R) : 0.5 g

Additional vol of F : 5 ml

No	Expt	Product	G or Pg	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of first reaction (min)	Time of reaction after addition of R & F (min)	Wt of product (g)
1	19ARm (WB)	M19KPFRw	G	-	3.6	30	90	2.5
2	25ARm (WB)	M25KPFRw	Pg	-	3.6	30	70	1.6
3	19A'Rm (WB)	M19KPFRcw	G	3	3.6	30	75	2.1
4	25A'Rm (WB)	M25KPFRcw	Pg	3	3.6	30	90	1.0

the membrane in water bath (WB) at 80-90°C for 24 hours. The membrane was washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.29(b).

7(c) Preparation of chelating membrane using polyvinyl alcohol, ethyl acetoacetate, formaldehyde and resorcinol

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Ethyl acetoacetate in presence or absence of starch solution and sodium carbonate solution were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then resorcinol and formaldehyde were added to the above mixture followed with or without HCl and heating at 70-80°C was continued further. The gel obtained was pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured (i) by separating it from glass-plates and keeping it for 24 hours on steam bath (SB) at about 100°C or (ii) by dipping gel with glass-plates with the membrane in water bath (WB) at 80-90°C for 24 hours. The membrane was then washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amount of reactants used, time of reaction, yield of the product, etc, are given in the table II.29(c).

Table II.29(b)

Wt of PVA (KL grade) : 3 g

Wt of resorcinol (R) : 0.5 g

Additional vol of F : 5 ml

No 1	Expt 2	Product 3	Vol of F (ml) 4	Wt of starch (c) (g) 5	Wt of Na_2CO_3 (g) 6	Time of reaction (i) (min) 7	Wt of 8-hydroxy quinoline (Q) (g) 8	Time of reaction (ii) (min) 9	Wt of product (g) 10
1	5CRm (SB)	M5KPFQR	1	-	0.1	30	0.5	40	4.1
2	6CRm (SB)	M6KPFQR	5	-	0.1	30	1.0	60	4.2
3	7CRm (SB)	M7KPFQR	5	-	0.1	30	3.0	90	5.1
4	5C'Rm(SB)	M5KPFQRc	1	3	0.1	30	0.5	60	3.9
5	6C'Rm(SB)	M6KPFQRc	5	3	0.1	30	1.0	60	4.2
6	7C'Rm(SB)	M7KPFQRc	5	3	0.1	30	3.0	50	6.0

Table II.29(b) (contd.)

1	2	3	4	5	6	7	8	9	10
7	5CRm (WB)	M5KPFQRw	1	-	0.1	30	0.5	40	4.1
8	6CRm (WB)	M6KPFQRw	5	-	0.1	30	1.0	60	4.4
9	7CRm (WB)	M7KPFQRw	5	-	0.1	30	3.0	90	4.6
10	5C'Rm(WB)	M5KPFQRcw	1	3	0.1	30	0.5	60	3.8
11	6C'Rm(WB)	M6KPFQRcw	5	3	0.1	30	1.0	60	4.4
12	7C'Rm(WB)	M7KPFQRcw	5	3	0.1	30	3.0	50	4.4

Table II.29(c)

Wt of PVA (KL grade) : 3 g
Wt of resorcinol (R) : 0.5 g
Vol of F : 5 ml

No	Expt	Product	Vol of ethyl aceto-acetate (E) (ml)	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Vol of HCl (ml)	Time of reaction (ii) (min)	Wt of product (g)
1	3ERm (SB)	M3KPERF	2	-	1	30	-	10	4.7
2	5ERm (SB)	M5KPERF	1	-	1	30	1	30	4.0
3	3E'Rm(SB)	M3KPERFc	2	3	1	30	-	10	6.6
4	5E'Rm(SB)	M5KPERFc	1	3	1	30	1	40	4.1
5	3ERm (WB)	M3KPERFw	2	-	1	30	-	10	2.8
6	5ERm (WB)	M5KPERFw	1	-	1	30	1	30	2.2
7	3E'Rm(WB)	M3KPERFcw	2	3	1	30	-	10	3.5
8	5E'Rm(WB)	M5KPERFcw	1	3	1	30	1	40	2.7

7(d) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, chloral hydrate and resorcinol

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Chloral hydrate in presence or absence of starch solution and sodium carbonate solution were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then resorcinol and formaldehyde were added to the above mixture and heating at 70-80°C was continued further. The gel obtained was pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured (i) by separating it from glass-plates and keeping it on steam bath (SB) at about 100°C for 24 hours or (ii) by dipping gel with glass-plates with the membrane in water bath (WB) at 80-90°C for 24 hours. The membrane was then washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.29(d).

7(e) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, starch, salicylic acid, resorcinol and ammonium nitrate

Polyvinyl alcohol (KL grade) and glycerine (or polyethylene glycol) were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde, starch, salicylic

Table II.29(d)

Wt of PVA (KL grade) : 3 g

Wt of chloral hydrate (Cl) : 1 g

Wt of resorcinol (R) : 0.5 g

Vol of F : 5 ml

No	Expt	Product	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	1HRm (SB)	M1KPClRF	-	0.1	30	90	3.4
2	3HRm (SB)	M3KPClRF	-	1.0	30	10	3.5
3	1H'Rm (SB)	M1KPClRFc	3	0.1	30	90	4.1
4	3H'Rm (SB)	M3KPClRFc	3	1.0	30	15	3.5
5	1HRm (WB)	M1KPClRFw	-	0.1	30	90	2.7
6	3HRm (WB)	M3KPClRFw	-	1.0	30	10	3.2
7	1H'Rm (WB)	M1KPClRFcw	3	0.1	30	90	3.5
8	3H'Rm (WB)	M3KPClRFcw	3	1.0	30	15	3.2

acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then resorcinol and additional amount of formaldehyde were added followed by solid ammonium nitrate and heating at 70-80°C was continued further. The gel obtained was cooled and then pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in table II.29(e).

7(f) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, starch, salicylic acid, 8-hydroxy quinoline, resorcinol and ammonium nitrate

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde, starch, salicylic acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then resorcinol, additional amount of formaldehyde and 8-hydroxy quinoline dissolved in hydrochloric acid were added to the above mass followed by solid ammonium nitrate and heating at 70-80°C was continued further. The gel obtained was cooled and then pressed

Table II.29(e)

Wt of PVA (KL grade) : 3 g

Vol of F : 10 ml

Vol of G or Pg : 10 ml

Wt of salicylic acid (Sd) : 0.5 g

Wt of resorcinol (R) : 0.5 g

Additional vol of F : 5 ml

Wt of NH_4NO_3 : 30 g

No	Expt	Product	Wt of starch (c) (g)	G or Pg	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	1A'SRm	M1KPFSdRc	3	G	1	30	10	3.5
2	2A'SRm	M2KPFSdRc	3	Pg	1	30	10	3.1

between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in table II.29(f).

7(g) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, starch, ethyl acetoacetate, salicylic acid, resorcinol and ammonium nitrate

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Ethyl acetoacetate, starch, salicylic acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then resorcinol and formaldehyde with or without hydrochloric acid were added to the above mass followed by solid ammonium nitrate and heating at 70-80°C was continued further. The gel obtained was cooled and pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in the table II.29(g).

Table II.29(f)

Wt of PVA (KL grade) : 3 g

Vol of F : 10 ml

Wt of salicylic acid (Sd) : 0.5 g

Wt of resorcinol (R) : 0.5 g

Additional vol of F : 5 ml

Wt of NH_4NO_3 : 30 g

No	Expt	Product	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (I) (min)	Wt of 8-hydroxy quinoline (Q) (g)	Time of reaction (II) (min)	Wt of product (g)
1	1C'SRm	M1KPFSdQRc	3	0.1	30	0.5	5	3.9
2	2C'SRm	M2KPFSdQRc	3	0.1	30	1.0	5	3.9
3	3C'SRm	M3KPFSdQRc	3	0.1	30	3.0	5	3.9

Table II.29(g)

Wt of PVA (KL grade) : 3 g
Wt of salicylic acid (Sd): 0.5 g
Wt of resorcinol (R) : 0.5 g
Vol of F : 5 ml
Wt of NH_4NO_3 : 30 g

No	Expt	Product	Vol of ethyl aceto-acetate (E) (ml)	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Vol of HCl (ml)	Time of reaction (ii) (min)	Wt of product (g)
1	1E'SRm	M1KPESdRFc	2	3	1	30	-	5	3.9
2	2E'SRm	M2KPESdRFc	1	3	1	30	1	5	3.7

7(h) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, starch, chloral hydrate, salicylic acid, resorcinol and ammonium nitrate

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Chloral hydrate, starch, salicylic acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then resorcinol and formaldehyde were added to the above mass followed by solid ammonium nitrate, and heating at 70-80°C was continued further. The gel obtained was cooled and pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in table II.29(h).

7(j) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, starch, salicylic acid, melamine and ammonium nitrate

Polyvinyl alcohol (KL grade) and glycerine (or polyethylene glycol) were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde, starch, salicylic acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C

Table II.29(h)

Wt of PVA (KL grade) : 3 g
Wt of salicylic acid (Sd) : 0.5 g
Wt of resorcinol (R) : 0.5 g
Vol of F : 5 ml
Wt of NH_4NO_3 : 30 g

No	Expt	Product	Wt of chloral hydrate (Cl) (g)	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	1H'SRm	M1KPClSdRFc	1	3	0.1	30	5	2.7
2	2H'SRm	M2KPClSdRFc	1	3	1.0	30	5	3.3

with occasional shaking for definite time. Then melamine and additional amount of formaldehyde were added followed by solid ammonium nitrate and heating at 70-80°C was continued further. The gel obtained was cooled and then pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in table II.29(j).

7(k) Preparation of chelating membrane using polyvinyl alcohol, formaldehyde, starch, salicylic acid, 8-hydroxy quinoline, melamine and ammonium nitrate

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Formaldehyde, starch, salicylic acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then melamine, additional amount of formaldehyde and 8-hydroxy quinoline dissolved in hydrochloric acid were added to the above mass followed by solid ammonium nitrate and heating at 70-80°C was continued further. The gel obtained was cooled and then pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours,

Table II.29(j)

Wt of PVA (KL grade) : 3 g
Vol of F : 10 ml
Vol of G or Pg : 10 ml
Wt of salicylic acid (Sd) : 0.5 g

Wt of melamine (m) : 0.5 g
Additional vol of F : 5 ml
Wt of NH_4NO_3 : 30 g

No	Expt	Product	Wt of starch (c) (g)	G or Pg	Wt of Na_2CO_3 (g)	Time of reaction (I) (min)	Time of reaction (II) (min)	Wt of product (g)
1	1A'SMm	M1KPFSdmc	6	G	1	40	5	4.5
2	2A'SMm	M2KPFSdmc	6	Pg	1	35	5	5.3

washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in table II.29(k).

7(l) Preparation of chelating membrane using polyvinyl alcohol, butyraldehyde, starch, ethyl acetoacetate, salicylic acid, melamine and ammonium nitrate

Polyvinyl alcohol (KL grade) and water were taken in 250 ml round bottom flask fitted with reflux condenser. Ethyl acetoacetate, starch, salicylic acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then melamine and butyraldehyde were added to the above mass followed by solid ammonium nitrate and heating at 70-80°C was continued further. The gel obtained was cooled and pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in table II.29(l).

7(m) Preparation of chelating membrane using polyvinyl alcohol, butyraldehyde, starch, chloral hydrate, salicylic acid, melamine and ammonium nitrate

Polyvinyl alcohol (KL grade) and water were taken in

Table II.29(k)

Wt of PVA (KL grade) : 3 g
Vol of F : 10 ml
Wt of salicylic acid (Sd) : 0.5 g
Wt of melamine (m) : 0.5 g
Additional vol of F : 5 ml
Wt of NH_4NO_3 : 30 g

No	Expt	Product	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Wt of 8-hydroxy quinoline (Q) (g)	Time of reaction (ii) (min)	Wt of product (g)
1	1C'SMm	M1KPFSdQmc	6	0.1	35	0.5	5	3.7
2	2C'SMm	M2KPFSdQmc	6	0.1	35	1.0	5	3.4
3	3C'SMm	M3KPFSdQmc	6	0.1	35	3.0	5	3.1

Table II.29(1)

Wt of PVA (KL grade) : 3 g

Wt of salicylic acid (Sd) : 0.5 g

Wt of melamine (m) : 1 g

Vol of butyraldehyde (B') : 2 ml

Wt of NH_4NO_3 : 25 g

No	Expt	Product	Vol of ethyl aceto-acetate (E) (ml)	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	1E'SMB'm	M1KPESdmB'c	2	6	1	30	5	2.8
2	2E'SMB'm	M2KPESdmB'c	1	6	1	30	5	2.2

250 ml round bottom flask fitted with reflux condenser. Chloral hydrate, starch, salicylic acid and sodium carbonate solutions were added to the mass. The reaction mixture was heated on water bath at 70-80°C with occasional shaking for definite time. Then melamine and butyraldehyde were added to the above mass followed by solid ammonium nitrate and heating at 70-80°C was continued further. The gel obtained was cooled and pressed between two glass-plates applying mild pressure and kept overnight. The membrane formed was cured in glycerine at 60-70°C for 24 hours, washed with water, acid, alkali, acid, water and alcohol respectively, dried and then used for investigations. The amounts of reactants used, time of reaction, yield of the product, etc, are given in table II.29(m).

The solubility of all these products (II.29) have been studied in different solvents and the data are presented in table II.30.

H-form of the resin having 35-100 BSS mesh size was used for studying water content of the resin, % sorption of water by the resin, Cu(II) ion uptake, Ni(II) ion uptake and Zn(II) ion uptake. The data are presented in tables II.31, II.32, II.33, II.34 and II.35 respectively.

The results obtained are discussed in the following chapter.

Table II.29(m)

Wt of PVA (KL grade) : 3 g
Wt of salicylic acid (Sd): 0.5 g
Wt of melamine (m) : 1 g
Vol of butyraldehyde (B') : 2 ml
Wt of NH_4NO_3 : 25 g

No	Expt	Product	Wt of chloral hydrate (Cl) (g)	Wt of starch (c) (g)	Wt of Na_2CO_3 (g)	Time of reaction (i) (min)	Time of reaction (ii) (min)	Wt of product (g)
1	1H'SMB'm	M1KPClSdmB'c	1	6	0.1	35	5	1.8
2	2H'SMB'm	M2KPClSdmB'c	1	6	1.0	40	5	1.5

Table II.30(a)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	19ARm (WB)	M19KPFRw	reddish brown	p	p	i	i	i	i
2	25ARm (WB)	M25KPFRw	reddish brown	p	p	i	i	i	i
3	19A'Rm(WB)	M19KPFRcw	reddish brown	p	p	i	i	i	i
4	25A'Rm(WB)	M25KPFRcw	reddish brown	p	p	i	i	i	i

Table II.30(b)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	5CRm (SB)	M5KPFQR	Orange	p	p	i	i	i	i
2	6CRm (SB)	M6KPFQR	orange	p	p	i	i	i	i
3	7CRm (SB)	M7KPFQR	orange	p	p	i	i	i	i
4	5C'Rm(SB)	M5KPFQRc	reddish brown	p	p	i	i	i	i
5	6C'Rm(SB)	M6KPFQRc	reddish brown	p	p	i	i	i	i
6	7C'Rm(SB)	M7KPFQRc	reddish brown	p	p	i	i	i	i
7	5CRm (WB)	M5KPFQRw	orange	p	p	i	i	i	i
8	6CRm (WB)	M6KPFQRw	orange	p	p	i	i	i	i
9	7CRm (WB)	M7KPFQRw	orange	p	p	i	i	i	i
10	5C'Rm(WB)	M5KPFQRcw	reddish brown	p	p	i	i	i	i
11	6C'Rm(WB)	M6KPFQRcw	reddish brown	p	p	i	i	i	i
12	7C'Rm(WB)	M7KPFQRcw	reddish brown	p	p	i	i	i	i

Table II.30(c)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	3ERm (SB)	M3KPERF	reddish brown	p	p	i	i	i	i
2	5ERm (SB)	M5KPERF	reddish brown	p	p	i	i	i	i
3	3E'Rm(SB)	M3KPERFc	reddish brown	p	p	i	i	i	i
4	5E'Rm(SB)	M5KPERFc	reddish brown	p	p	i	i	i	i
5	3ERm (WB)	M3KPERFw	reddish brown	p	p	i	i	i	i
6	5ERm (WB)	M5KPERFw	reddish brown	p	p	i	i	i	i
7	3E'Rm(WB)	M3KPERFcw	reddish brown	p	p	i	i	i	i
8	5E'Rm(WB)	M5KPERFcw	reddish brown	p	p	i	i	i	i

Table II.30(d)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Bezene	DMF
1	1HRm (SB)	M1KPClRF	reddish brown	p	p	i	i	i	i
2	3HRm (SB)	M3KPClRF	reddish brown	p	p	i	i	i	i
3	1H'Rm(SB)	M1KPClRFc	reddish brown	p	p	i	i	i	i
4	3H'Rm(SB)	M3KPClRFc	reddish brown	p	p	i	i	i	i
5	1HRm (WB)	M1KPClRFw	reddish brown	p	p	i	i	i	i
6	3HRm (WB)	M3KPClRFw	reddish brown	p	p	i	i	i	i
7	1H'Rm(WB)	M1KPClRFcw	reddish brown	p	p	i	i	i	i
8	3H'Rm(WB)	M3KPClRFcw	reddish brown	p	p	i	i	i	i

Table II.30(e)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1A'SRm	M1KPFSdRc	orange	p	p	i	i	i	i
2	2A'SRm	M2KPFSdRc	orange	p	p	i	i	i	i

Table II.30(f)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1C'SRm	M1KPFSdQRc	brown	p	p	i	i	i	i
2	2C'SRm	M2KPFSdQRc	brown	p	p	i	i	i	i
3	3C'SRm	M3KPFSdQRc	Yellow	p	p	i	i	i	i

Table II.30(g)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1E'SRm	M1KPESdRFc	orange	p	p	i	i	i	i
2	2E'SRm	M2KPESdRFc	reddish brown	p	p	i	i	i	i

Table II.30(h)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1H'SRm	M1KPClSdRFc	white	p	p	i	i	i	i
2	2H'SRm	M2KPClSdRFc	yellow	p	p	i	i	i	i

Table II.30(j)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1A'SMm	M1KPFSdmc	white	p	p	i	i	i	i
2	2A'SMm	M2KPFSdmc	white	p	p	i	i	i	i

Table II.30(k)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1C'SMm	M1KPFSdQmc	yellow	p	p	i	i	i	i
2	2C'SMm	M2KPFSdQmc	brown	p	p	i	i	i	i
3	3C'SMm	M3KPFSdQmc	brown	p	p	i	i	i	i

Table II.30(1)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1E'SMB'm	M1KPESdmB'c	light brown	p	p	i	i	i	i
2	2E'SMB'm	M2KPESdmB'c	dark brown	p	p	i	i	i	i

Table II.30(m)

No	Expt	Product	Colour	Solubility in					
				1N HCl	1N NaOH	Alcohol	Acetone	Benzene	DMF
1	1H'SMB'm	M1KPClSdmB'c	light brown	p	p	i	i	i	i
2	2H'SMB'm	M2KPClSdmB'c	light brown	p	p	i	i	i	i

Table II.31(a)

No	Expt	Product	Water content %	Solid content %
1	19ARm (WB)	M19KPFRw	5.4	94.6
2	25ARm (WB)	M25KPFRw	8.8	91.2
3	19A'Rm(WB)	M19KPFRcw	3.3	96.7
4	25A'Rm(WB)	M25KPFRcw	12.8	87.2

Table II.31(b)

No 1	Expt 2	Product 3	Water content % 4	Solid content % 5
1	5CRm (SB)	M5KPFQR	5.7	94.3
2	6CRm (SB)	M6KPFQR	4.7	95.3
3	7CRm (SB)	M7KPFQR	5.5	94.5
4	5C'Rm(SB)	M5KPFQRc	2.5	97.5
5	6C'Rm(SB)	M6KPFQRc	4.8	95.2
6	7C'Rm(SB)	M7KPFQRc	4.2	95.8
7	5CRm(WB)	M5KPFQRw	4.7	95.3

Table II.31(b) (contd.)

1	2	3	4	5
8	6CRm (WB)	M6KPFQRw	4.1	95.9
9	7CRm (WB)	M7KPFQRw	4.5	95.5
10	5C'Rm(WB)	M5KPFQRcw	3.8	96.2
11	6C'Rm(WB)	M6KPFQRcw	2.1	97.9
12	7C'Rm(WB)	M7KPFQRcw	3.8	96.2

Table II.31(c)

No	Expt	Product	Water content %	Solid content %
1	3ERm (SB)	M3KPERF	4.0	96.0
2	5ERm (SB)	M5KPERF	4.9	95.1
3	3E'Rm(SB)	M3KPERFc	3.1	96.9
4	5E'Rm(SB)	M5KPERFc	2.4	97.6
5	3ERm (WB)	M3KPERFw	5.3	94.7
6	5ERm (WB)	M5KPERFw	4.2	95.8
7	3E'Rm (WB)	M3KPERFcw	2.9	97.1
8	5E'Rm (WB)	M5KPERFcw	2.3	97.7

Table II.31(d)

No	Expt	Product	Water content %	Solid content %
1	1HRm (SB)	M1KPC1RF	3.3	96.7
2	3HRm (SB)	M3KPC1RF	2.0	98.0
3	1H'Rm(SB)	M1KPC1RFc	2.8	97.2
4	3H'Rm(SB)	M3KPC1RFc	2.4	97.6
5	1HRm (WB)	M1KPC1RFw	4.0	96.0
6	3HRm (WB)	M3KPC1RFw	5.1	94.9
7	1H'Rm(WB)	M1KPC1RFcw	2.0	98.0
8	3H'Rm(WB)	M3KPC1RFcw	3.1	96.9

Table II.32(a)

No.	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	19ARm (WB)	M19KPFRw	0.60	0.00
2	25ARm (WB)	M25KPFRw	0.77	0.00
3	19A'Rm(WB)	M19KPFRcw	0.65	0.00
4	25A'Rm(WB)	M25KPFRcw	1.51	0.00

Table II.32(b) (contd.)

1	2	3	5	6
8	6CRm (WB)	M6KPFQRw	0.51	0.04
9	7CRm (WB)	M7KPFQRw	0.49	0.14
10	5C'Rm(WB)	M5KPFQRcw	1.02	0.07
11	6C'Rm(WB)	M6KPFQRcw	0.67	0.28
12	7C'Rm(WB)	M7KPFQRcw	0.92	0.24

Table II.32(c)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	3ERm (SB)	M3KPERF	0.47	0.00
2	5ERm (SB)	M5KPERF	0.37	0.00
3	3E'Rm(SB)	M3KPERFc	1.48	0.00
4	5E'Rm(SB)	M5KPERFc	1.05	0.00
5	3ERm (WB)	M3KPERFw	0.56	0.00
6	5ERm (WB)	M5KPERFw	0.70	0.00
7	3E'Rm(WB)	M3KPERFcw	1.22	0.00
8	5E'Rm(WB)	M5KPERFcw	0.98	0.04

Table II.32(d)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1HRm (SB)	M1KPC1RF	0.50	0.00
2	3HRm (SB)	M3KPC1RF	0.51	0.00
3	1H'Rm(SB)	M1KPC1RFc	1.00	0.00
4	3H'Rm(SB)	M3KPC1RFc	0.90	0.00
5	1HRm (WB)	M1KPC1RFw	1.23	0.00
6	3HRm (WB)	M3KPC1RFw	0.60	0.00
7	1H'Rm (WB)	M1KPC1RFcw	0.90	0.08
8	3H'Rm (WB)	M3KPC1RFcw	0.98	0.06

Table II.32(e)

No.	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1A'SRm	M1KPFSdRc	0.68	0.18
2	2A'SRm	M2KPFSdRc	1.11	0.80

Table II.32(f)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1C'SRm	M1KPFSdQRc	0.77	0.33
2	2C'SRm	M2KPFSdQRc	0.71	0.43
3	3C'SRm	M3KPFSdQRc	0.64	0.43

Table II.32(g)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/1 (g/1)
1	1E'SRm	M1KPESdRFc	1.71	0.50
2	2E'SRm	M2KPESdRFc	1.15	0.45

Table II.32(h)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1H'SRm	M1KPC1SdRFc	2.13	0.73
2	2H'SRm	M2KPC1SdRFc	1.70	0.90

Table II.32(j)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1A'SMm	M1KPFSdmc	0.76	0.00
2	2A'SMm	M2KPFSdmc	0.64	0.00

Table II.32(k)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1C'SMm	M1KPFSdQmc	1.04	0.00
2	2C'SMm	M2KPFSdQmc	0.66	0.00
3	3C'SMm	M3KPFSdQmc	1.00	0.00

Table II.32(1)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1E'SMB'm	M1KPESdmB'c	2.16	0.53
2	2E'SMB'm	M2KPESdmB'c	1.07	0.68

Table II.32(m)

No	Expt	Product	Sample in Water	
			Wt gain/g (g/g)	Wt loss/l (g/l)
1	1H'SMB'm	M1KPC1SdmB'c	1.19	0.50
2	2H'SMB'm	M2KPC1SdmB'c	0.84	0.00

Table II.33(a)

pH of Cu(II) solution ~ 10

No	Expt	Product	Amount of Cu(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	19ARm(WB)	M19KPFRw	1.87	0.10
2	25ARm(WB)	M25KPFRw	3.52	0.28
3	19A'Rm(WB)	M19KPFRcw	1.83	0.22
4	25A'Rm(WB)	M25KPFRcw	5.67	0.43

Table II.33(b)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	5CRm(SB)	M5KPFQR	1.16	0.11
2	6CRm(SB)	M6KPFQR	1.12	0.11
3	7CRm(SB)	M7KPFQR	1.08	0.11
4	5C'Rm(SB)	M5KPFQRc	1.26	0.05
5	6C'Rm(SB)	M6KPFQRc	1.21	0.07
6	7C'Rm(SB)	M7KPFQRc	1.02	0.08

Table II.33(b) (contd)

1	2	3	4	5
7	5CRm(WB)	M5KPFQRw	1.17	0.03
8	6CRm(WB)	M6KPFQRw	1.07	0.03
9	7CRm(WB)	M7KPFQRw	0.98	0.03
10	5C'Rm(WB)	M5KPFQRcw	1.05	0.14
11	6C'Rm(WB)	M6KPFQRcw	0.84	0.16
12	7C'Rm(WB)	M7KPFQRcw	0.84	0.17

Table II.33(c)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	3ERm(SB)	M3KPERF	1.02	0.12
2	5ERm(SB)	M5KPERF	1.28	0.09
3	3E'Rm(SB)	M3KPERFc	0.81	0.17
4	5E'Rm(SB)	M5KPERFc	1.09	0.24
5	3ERm(WB)	M3KPERFw	1.64	0.11
6	5ERm(WB)	M5KPERFw	1.40	0.13
7	3E'Rm(WB)	M3KPERFcw	1.08	0.16
8	5E'Rm(WB)	M5KPERFcw	1.49	0.13

Table II.33(d)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1HRm(SB)	M1KPC1RF	1.36	0.15
2	3HRm(SB)	M3KPC1RF	1.32	0.13
3	1H'Rm(SB)	M1KPC1RFc	1.20	0.17
4	3H'Rm(SB)	M3KPC1RFc	1.37	0.21
5	1HRm(WB)	M1KPC1RFw	1.73	0.15
6	3HRm(WB)	M3KPC1RFw	1.43	0.10
7	1H'Rm(WB)	M1KPC1RFcw	1.14	0.12
8	3H'Rm(WB)	M3KPC1RFcw	1.45	0.12

Table II.33(e)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1A'SRm	M1KPFSdRc	1.27	0.10
2	2A'SRm	M2KPFSdRc	1.38	0.08

Table II.33(f)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1C'SRm	M1KPFSdQRc	1.21	0.04
2	2C'SRm	M2KPFSdQRc	1.19	0.06
3	3C'SRm	M3KPFSdQRc	1.13	0.10

Table II.33(g)

pH of Cu(II) solution ~ 10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1E'SRm	M1KPESdRFc	1.25	0.09
2	2E'SRm	M2KPESdRFc	1.34	0.06

Table II.33(h)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1H'SRm	M1KPClSdRFc	2.31	0.06
2	2H'SRm	M2KPClSdRFc	1.53	0.15

Table II.33(j)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1A'SMm	M1KPFSdmc	1.39	0.34
2	2A'SMm	M2KPFSdmc	1.37	0.17

Table II.33(k)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1C'SMm	M1KPFSdQmc	1.32	0.21
2	2C'SMm	M2KPFSdQmc	1.26	0.22
3	3C'SMm	M3KPFSdQmc	1.43	0.23

Table II.33(1)

pH of Cu(II) solution ~10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1E'SMBm	M1KPESdmBc	1.72	0.12
2	2E'SMBm	M2KPESdmBc	2.25	0.15

Table II.33(m)

pH of Cu(II) solution $\sim$10

No	Expt	Product	Amount of Cu(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1H'SMBm	M1KPClSdmBc	2.91	0.21
2	2H'SMBm	M2KPClSdmBc	2.98	0.28

Table II.34(a)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	19ARm(WB)	M19KPFRw	3.38	0.05
2	25ARm(WB)	M25KPFRw	6.01	0.15
3	19A'Rm(WB)	M19KPFRcw	4.27	0.11
4	25A'Rm(WB)	M25KPFRcw	12.94	0.56

Table II.34(b)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	2	3	4	5
1	5CRm(SB)	M5KPFQR	2.44	0.04
2	6CRm(SB)	M6KPFQR	2.35	0.04
3	7CRm(SB)	M7KPFQR	2.00	0.04
4	5C'Rm(SB)	M5KPFQRc	2.22	0.05
5	6C'Rm(SB)	M6KPFQRc	2.19	0.05
6	7C'Rm(SB)	M7KPFQRc	2.02	0.06

Table II.34(b) (contd.)

1	2	3	4	5
7	5CRm(WB)	M5KPFQRw	2.03	0.04
8	6CRm(WB)	M6KPFQRw	1.87	0.03
9	7CRm(WB)	M7KPFQRw	1.81	0.04
10	5C'Rm(WB)	M5KPFQRcw	2.45	0.13
11	6C'Rm(WB)	M6KPFQRcw	2.04	0.10
12	7C'Rm(WB)	M7KPFQRcw	2.19	0.08

Table II.34(c)

pH of Ni(II) solution $\sim$ 10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	3ERm(SB)	M3KPERF	2.08	0.09
2	5ERm(SB)	M5KPERF	2.47	0.10
3	3E'Rm(SB)	M3KPERFc	2.01	0.05
4	5E'Rm(SB)	M5KPERFc	2.45	0.02
5	3ERm(WB)	M3KPERFw	2.97	0.06
6	5ERm(WB)	M5KPERFw	2.55	0.05
7	3ERm(WB)	M3KPERFcw	2.62	0.09
8	5E'Rm(WB)	M5KPERFcw	3.39	0.10

Table II.34(d)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1HRm(SB)	M1KPClRF	2.80	0.11
2	3HRm(SB)	M3KPClRF	2.68	0.11
3	1H'Rm(SB)	M1KPClRFc	2.45	0.07
4	3H'Rm(SB)	M3KPClRFc	2.72	0.08
5	1HRm(WB)	M1KPClRFw	3.16	0.06
6	3HRm(WB)	M3KPClRFw	2.58	0.05
7	1H'Rm(WB)	M1KPClRFcw	2.63	0.10
8	3H'Rm(WB)	M3KPClRFcw	3.33	0.10

Table II.34(e)

pH of Ni(II) solution $\sim$ 10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1A'SRm	M1KPFSdRc	2.41	0.00
2	2A'SRm	M2KPFSdRc	2.49	0.00

Table II.34(f)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1C'SRm	M1KPFSdQRc	2.10	0.02
2	2C'SRm	M2KPFSdQRc	2.09	0.03
3	3C'SRm	M3KPFSdQRc	2.10	0.05

Table II.34(g)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1E'SRm	M1KPESdRFc	2.42	0.00
2	2E'SRm	M2KPESdRFc	2.39	0.09

Table II.34(h)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1H'SRm	M1KPC1SdRFc	4.06	0.00
2	2H'SRm	M2KPC1SdRFc	3.04	0.03

Table II.34(j)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1A'SMm	M1KPFSdmc	3.04	0.03
2	2A'SMm	M2KPFSdmc	2.62	0.06

Table II.34(k)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1C'SMm	M1KPFSdQmc	2.63	0.02
2	2C'SMm	M2KPFSdQmc	2.52	0.03
3	3C'SMm	M3KPFSdQmc	2.86	0.03

Table II.34(1)

pH of Ni(II) solution ~10

No	Expt	Product	Amount of Ni(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1E'SMB'm	M1KPESdmB'c	3.66	0.02
2	2E'SMB'm	M2KPESdmB'c	4.27	0.09

Table II.34(m)

pH of Ni(II) solution ~ 10

No	Expt	Product	Amount of Ni(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1H'SMB'm	M1KPClSdmB'c	5.85	0.06
2	2H'SMB'm	M2KPClSdmB'c	5.91	0.09

Table II.35(a)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	19ARm(WB)	M19KPFRw	4.23	0.11
2	25ARm(WB)	M25KPFRw	7.53	0.26
3	19A'Rm(WB)	M19KPFRcw	4.67	0.15
4	25A'Rm(WB)	M25KPFRcw	14.02	0.63

Table II.35(b)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	5CRm(SB)	M5KPFQR	2.39	0.05
2	6CRm(SB)	M6KPFQR	2.33	0.03
3	7CRm(SB)	M7KPFQR	2.02	0.03
4	5C'Rm(SB)	M5KPFQRc	2.37	0.12
5	6C'Rm(SB)	M6KPFQRc	2.34	0.10
6	7C'Rm(SB)	M7KPFQRc	2.15	0.11

Table II.35(b) (contd.)

1	2	3	4	5
7	5CRm(WB)	M5KPFQRw	2.52	0.09
8	6CRm(WB)	M6KPFQRw	2.34	0.05
9	7CRm(WB)	M7KPFQRw	2.22	0.10
10	5C'Rm(WB)	M5KPFQRcw	2.65	0.12
11	6C'Rm(WB)	M6KPFQRcw	2.18	0.13
12	7C'Rm(WB)	M7KPFQRcw	2.33	0.12

Table II.35(c)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	3ERm(SB)	M3KPERF	2.04	0.08
2	5ERm(SB)	M5KPERF	2.48	0.07
3	3E'Rm(SB)	M3KPERFc	2.27	0.11
4	5E'Rm(SB)	M5KPERFc	2.66	0.09
5	3ERm(WB)	M3KPERFw	3.66	0.14
6	5ERm(WB)	M5KPERFw	3.15	0.11
7	3E'Rm(WB)	M3KPERFcw	2.79	0.14
8	5E'Rm(WB)	M5KPERFcw	3.58	0.16

Table II.35(d)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1HRm(SB)	M1KPC1RF	2.81	0.08
2	3HRm(SB)	M3KPC1RF	2.67	0.08
3	1H'Rm(SB)	M1KPC1RFc	2.66	0.16
4	3H'Rm(SB)	M3KPC1RFc	2.90	0.15
5	1HRm(WB)	M1KPC1RFw	3.97	0.15
6	3HRm(WB)	M3KPC1RFw	3.21	0.10
7	1H'Rm(WB)	M1KPC1RFcw	2.83	0.14
8	3H'Rm(WB)	M3KPC1RFcw	3.57	0.13

Table II.35(e)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1A'SRm	M1KPFSdRc	2.98	0.03
2	2A'SRm	M2KPFSdRc	3.08	0.00

Table II.35(f)

pH of Zn(II) solution ∼10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1C'SRm	M1KPFSdQRc	2.62	0.07
2	2C'SRm	M2KPFSdQRc	2.59	0.05
3	3C'SRm	M3KPFSdQRc	2.60	0.03

Table II.35(g)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1E'SRm	M1KPESdRFc	3.01	0.03
2	2E'SRm	M2KPESdRFc	3.04	0.11

Table II.35(h)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1H'SRm	M1KPClSdRFc	5.08	0.04
2	2H'SRm	M2KPClSdRFc	3.77	0.03

Table II.35(j)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1A'SMm	M1KPFSdmc	3.80	0.06
2	2A'SMm	M2KPFSdmc	3.33	0.04

Table II.35(k)

pH of Zn(II) solution ~ 10

No	Expt	Product	Amount of Zn(II) (m.mole/g) at equilibrium	
			in solution	in resin phase
1	1C'SMm	M1KPFSdQmc	3.27	0.07
2	2C'SMm	M2KPFSdQmc	3.08	0.05
3	3C'SMm	M3KPFSdQmc	3.60	0.04

Table II.35(1)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1E'SMB'm	M1KPESdmB'c	4.62	0.04
2	2E'SMB'm	M2KPESdmB'c	5.44	0.11

Table II.35(m)

pH of Zn(II) solution ~10

No	Expt	Product	Amount of Zn(II) (m mole/g) at equilibrium	
			in solution	in resin phase
1	1H'SMB'm	M1KPClSdmB'c	7.79	0.06
2	2H'SMB'm	M2KPClSdmB'c	7.31	0.06

RESULTS and DISCUSSIONS