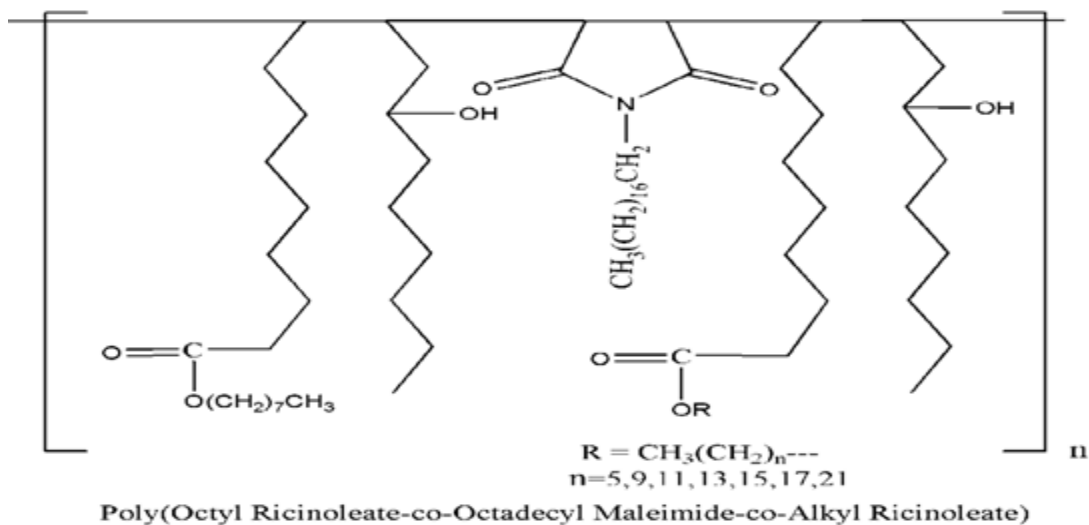


CHAPTER-4

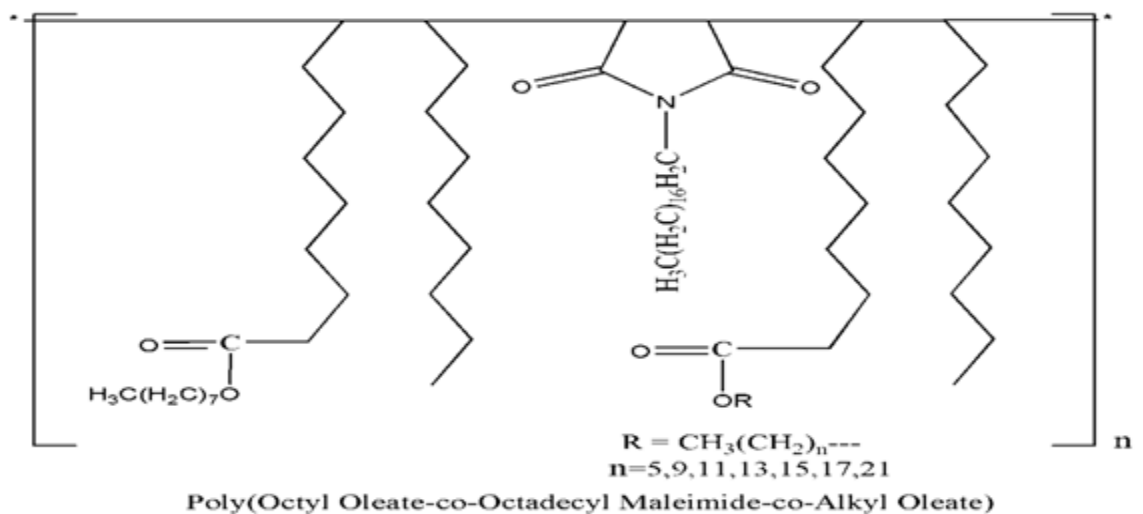
SUMMARY & CONCLUSION

Deposition of Wax in oil production forms a critical and difficult to control problem, in terms of production and operation cost, going from reservoir to surface facilities. In order to find suitable flow improvers for Kosamba-47, Kosamba-33 & Bombay High Crude oil, twenty eight new polymers were synthesized, possessing aliphatic and aromatic units as pendant chains with polar Nitrogen functional groups in their structure. The synthesized additives have dual behavior of flow improver and good pour point depressants. The additives can be categorized into four different classes based on basic polymeric unit and length of pendant alkyl chains. The structural formulas of synthesized four classes are shown as follows:

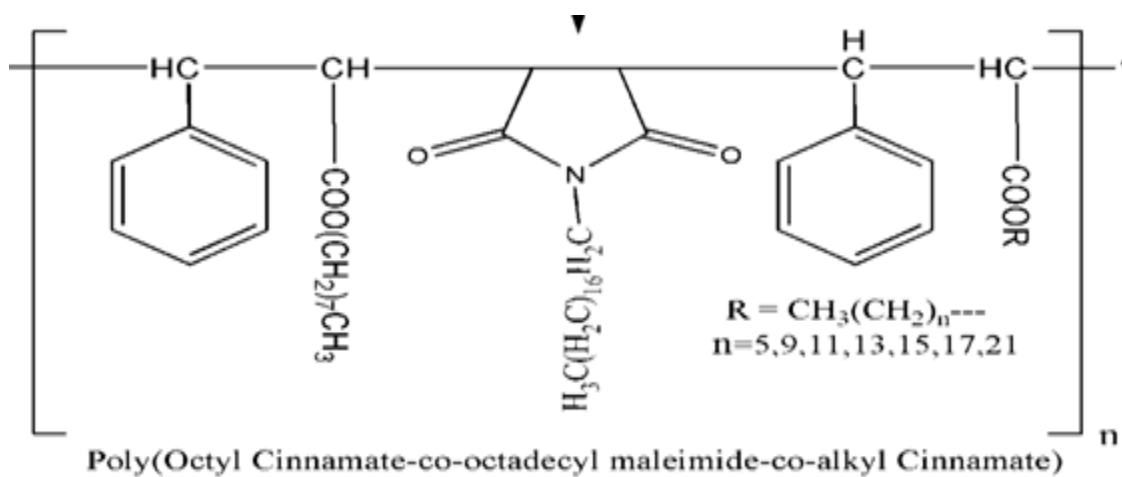
Class I



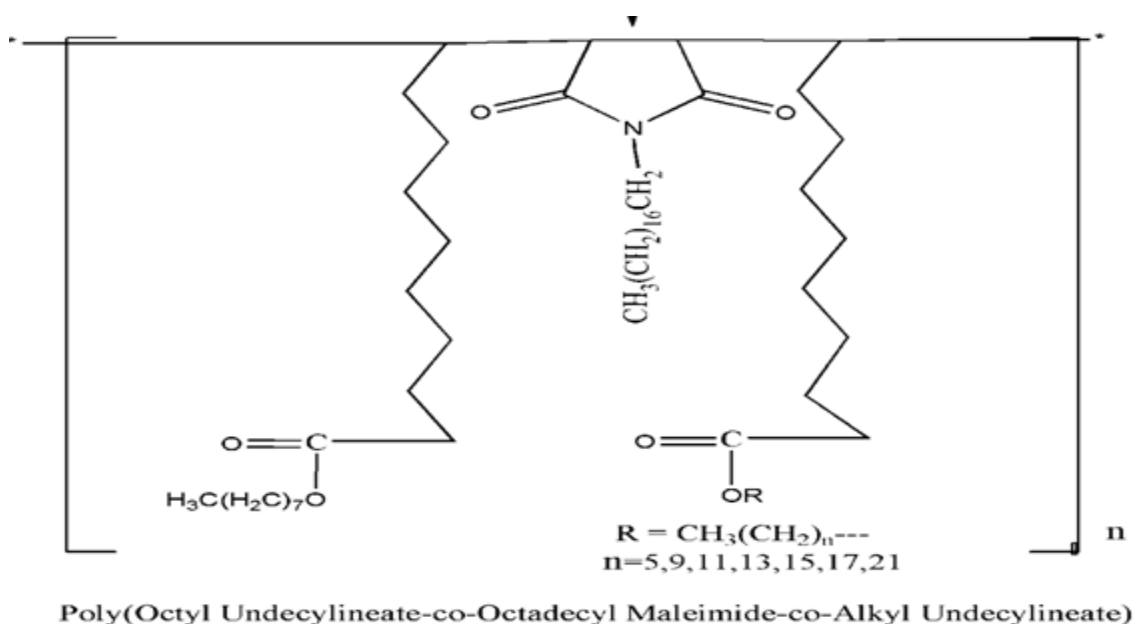
Class II



Class III



Class IV



Chapter 2 of the thesis describes the synthesis of polymeric additives by process of esterification, terpolymerization by free radical polymerization and insertion of polar Nitrogen group in the synthesized polymer at the different stages of the synthesis route. The structural elucidation were done by FTIR and GPC used for molecular weight determination.

Chapter 3 (I, II & III) of the thesis deals with testing of efficiency of prepared additives in terms of pour point depression and to study the effects of additives on rheological properties of Kosamba-33, Kosamba-47 and Bombay High crude oil. Complete method for pour point determination and rheological study is well explained in chapter-3 (I). As the determination of

the pour point proceeded, there was a growing realization of a probable correlation with molecular geometry of the copolymer indicating basic changes in polymeric pendant chains and structures. Not all the experimentally tested additives showed encouraging result. Therefore the results of some additives have been recorded and discussed. Some of these additives showed brilliant pour point depression property while others can be considered as good. Yield stress and viscosity of the crude oil at different temperatures and concentrations of additives were evaluated by zero friction advanced rheometer AR 1500 ex of TA instruments. The rheological data indicates selected crude oil have Bingham plastic nature. The synthesized four classes of polymeric flow improvers show variable results with respect to pour point depression and low temperature performance of the selected crude oils. Most additives could perform satisfactorily well.

From the previously described chapters, it can be seen that additives from any of the five series behaves differently with crude oils of different oil field. Not a single additive is equally effective on all the crude oils under study. Additives having C_{11} to C_{20} pendant alkyl chains are more efficient PPD for Kosamba-47 crude oil. C_{22} and above pendant alkyl chain makes polymeric chain bulky, decreasing their efficiency. Additives 8-16UA18N & 8-14OA18N brought significant reduction in viscosity & Yield value of Kosamba-47 crude oil. Reverse results were shown by 8-14UA18N, 8-6CA18N, 8-18CA18N, 8-14RA18N, 8-16RA18N and 8-16OA18N with increase in concentration of additive and pendant alkyl chain length.

For Kosamba-33 crude oil additives 8-12UA18N, 8-16UA18N, 8-6CA18N, 8-14CA18N, 8-12RA18N, 8-14RA18N, 8-6OA18N and 8-16OA18N showed good efficiency as pour point depressants. Additives having effective PPD behavior were found to have C_{13} to C_{20} pendant alkyl chain length. Also, the presence of aromatic ring made molecule more bulky which helped in improving its pour point depressing tendency. The result obtained clearly indicates that additives like 8-16UA18N, 8-14RA18N brought reasonably good reduction in viscosity of Kosamba-33 crude oil. Decrease in viscosity of crude oil decreased the yield stress also. The additives 8-12UA18N, 8-6CA18N, 8-14CA18N, 8-12RA18N, 8-6OA18N and 8-16OA18N showed reverse results of increasing viscosity of Kosamaba-33 crude oil. It was observed that with increase in concentration of additive, viscosity and yield stress increases. Flow behavior is affected. Hence, these additives were not suitable for Kosamba-33 crude oil.

For Bombay High crude oil, additives 8-6UA18N, 8-14UA18N, 8-14CA18N, 8-16CA18N, 8-14RA18N, 8-16RA18N, 8-14OA18N and 8-16OA18N showed good efficiency as pour point

depressants. Possible reason for good efficiency of these additives can be matching of carbon number of the wax present in Bombay High crude oil with pendant chain. Additives having effective PPD behavior were found to have C₁₃ to C₂₀ pendant alkyl chain length. Also the presence of aromatic ring made molecule more bulky which helped in improving its pour point depressing tendency. Additives like 8-14CA18N, 8-16CA18N & 8-16OA18N brought significant reduction in viscosity of Bombay High crude oil. As viscosity of crude oil decreases then the yield stress needed to start flow also decreases and so it is possible to keep crude oil in flowing condition even at low temperature. Other additives coded 8-6UA18N, 8-14UA18N, 8-14RA18N, 8-16RA18N and 8-14OA18N have given reverse results that is increased the viscosity of Bombay High crude oil. The reason for such high values of rheological parameters may be such that the polymer additive becomes insoluble in crude oil and forms aggregates, which precipitate out from the crude along with wax crystal without being properly adsorbed on the surface. Due to this, they cannot make a change in the crystal structure but instead, the pendant chains of polymers interlock into one another like a zipper. Now the polymer molecules cannot slide over one another which results in an increase in viscosity and yield value of the crude oil.

Polymeric flow improvers possess an oil soluble long chain alkyl group and a polar structure in the molecular set up. The long chain alkyl group can insert into the wax crystal from the crude oil and polar part exists on the surface of the wax crystal, thus inhibiting crystal lattice formation and decreasing wax crystal size. The prepared nitrogen containing one component polymeric structure exhibits dual function of pour point depression and flow improver simultaneously. They possess the advantage of inevitable compatibility in one compound. The depressing effect mainly depends on polar effect of nitrogen/oxygen containing functional groups incorporated in the terpolymer moiety. On the other hand, flow ability depends on well matching of pendant alkyl chain of terpolymer with average carbon number of paraffin content present in crude oil. The higher the paraffin contents in the crude oil, the lower the response to flow improvement.