SYNOPSIS OF Ph.D.

TITLED

DESIGN & DEVELOPMENT OF SURGICAL GOWNS TO ENHANCE ITS PERFORMANCE

SUBMITTED TO

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SYNOPSIS

1. Introduction

Textile materials have gradually taken an important place in the technical field in general and in medical field in particular. Medical textiles in different forms have found their way into a variety of applications such as protective medical apparel, surgical dressings, blood filters, sutures, various body implants etc. The materials that are used in contact with tissue, blood, cells, proteins or any other living substances are called biomaterials including metals, ceramics, natural fibres and their composites.

Medical textiles are defined as, 'the type of technical textiles which offer variety of technical and functional properties having applications in the field of medical and clinical care and are manufactured primarily for their technical performance and functional properties rather than their aesthetic or decorative characteristics'. The very main objective is to improve the standard and quality of health care delivery by minimizing the risk of infections. The applications of textile materials in medical and healthcare industries may be broadly classified as follows:

Classification of medical textiles:

a) **Non-implantable**: these are the finished textile materials such as bandages, gauzes, orthopaedic belts, plasters, pressure garments, swabs, wipes, wound dressings etc.
b) **Implantable**: these are materials implanted on or in the human body, such as sutures, heart valves, vascular grafts, artificial veins, artificial tendons and ligaments, artificial joints and bones, artificial skin, artificial cartilage etc.
c) **Extracorporeal**: these are extra corporeally mounted devices used to support the function of vital organs, such as kidney, liver, lung, heart-pacer etc.
d) **Hygiene**: these are primary healthcare products meant for protection, general health care and hygiene, including bedding and clothing, mattress covers, face masks, head and shoe covers, apparel, sterilization wraps, incontinence care pads, nappies, tampons, surgical gowns etc.

Medical garments:

Medical garments are hygiene class of medical textiles. These are apparels designed for people with medical problems and/or medical personnel for the functions within protection and treatment domains. Medical garments can be classified in three main functional domains on the basis of their specified functions.

a) **Protective**: One of the basic functions of medical garments is to provide protection for medical personnel or patients from bacteria, physiological liquids, biological pollution and various harmful substances. Most significant examples are scrubs, masks, patient gowns, surgeons' clothes, laboratory coats and surgical gowns.
b) **Treatment**: Medical garments can also have a significant impact on healing or for treatment purposes. Post-operative compression garments play a vital role in the

recovery process in cosmetic surgery. For example, pressure garments (PGs) are the major treatment modalities for hypertrophic scars, and compressive stockings are commonly used for the prevention and treatment of varicose veins.

c) **Caring**: Some users with physical and mental disabilities would suffer from an inability to dress them and would have difficulties in dressing due to their impairments. Various applications are compression stockings, wet dressing, hip protectors, wound dressing, incontinence diapers etc.

Surgical gowns:

Surgical gowns are examples of personal protective equipment used in health care settings. They are used to protect the wearer from the spread of infection or illness if the wearer comes in contact with potentially infectious liquid and solid material. This has become more important with the growing risk of HIV and other viruses. They may also be used to help prevent the gown wearer from contaminating vulnerable patients, such as those with weakened immune systems.

In the last few years, health care professionals have been faced with an increasing number of patients suffering from serious diseases, which are spread through microorganisms like Pseudomonas Aeruginosa, E. coli, Acinetobacter, Baumanni, Klebsiella Pneumoniae etc. Awareness and attitude of the consumers towards hygiene and active lifestyle has created a good deal of developments in medical textiles, which has also increased the potential of research and development in this field.

Gowns are one part of an infection-control strategy. However, with this protection, health care garments must also be comfortable and not restrict movement. Further it also needs to make the decision whether it is better to disinfect the used garment for its reuse or dispose it completely after each use. According to the Occupational Safety and Health Administration definition, there are two basic requirements for a protective textile garment:

i) It should prevent infectious materials from passing through the skin, and
ii) It should last long enough.

New terminology has described the barrier protection levels of the gowns as follows:

Level 1: *Minimal risk*, for example, during basic care, standard isolation, cover gown for visitors, or in a standard medical unit.

Level 2: *Low risk*, for example, during blood drawing, suturing, in the Intensive Care Unit (ICU), or a pathology lab.

Level 3: *Moderate risk*, for example, during arterial blood draw, inserting an Intravenous (IV) line, in the Emergency Room, or for trauma cases.

Level 4: *High risk*, for example, during long, fluid intense procedures, surgery, when pathogen resistance is needed or infectious diseases are suspected (non-airborne).

In last few years, many medical textile structures have been developed and various chemical treatments have also been developed which can control microbial growth and hence can be useful to the hospitals and health care professionals.

The basic demands to be fulfilled by surgical gowns are known, but no concrete data has been given for comfort related properties usually. People feel physically and mentally fit, only when they feel thermally well. Studies have proven that the thermal comfort of the clothing system can be predicted when the ambient climate, the workload and the textile and physical parameters of the clothing layers are known. Operating room heating, ventilation and air conditioning (O.R.H.V.A.C.) System is used in O.T. to control heating, ventilating and air conditioning. Generally Temperature and Relative Humidity is maintained at about 68-75° F (20-24°C) and 20 % to 60 % respectively.

The disposable surgical gowns recently in use in general are made of various synthetic materials which are generally not cost effective and eco-friendly. There is a need for developing fabric preferably from natural materials for making the reusable surgical gowns which has a potential to prevent infections, comfortable and cost effective in long run. The present study has been undertaken with the aim to enhance the performance of reusable cellulosic surgical gowns.

2. Literature Review

2.1 Surgical gowns

Choosing the right surgical gown is a balance between its protection and comfort properties. At present, the best thermal comfort achievable is reached by the gowns consisting of micro fibre woven fabrics. The high performance multiple use products made of three layered silicon laminates with different membranes are in use to produce surgical drapes and gowns. The layer of silicone is sandwiched between two textured polyester warp-knitted fabrics. This polyester fabric is suitable to produce reusable gowns. In recent time disposable surgical gowns produced from light weight nonwoven synthetic fabrics are in use in the developed countries. The polyester gowns are comfortable to the surgeons and possess good properties, which ideally a better-quality surgical gown should have. The Polyethylene (PE) coated Polypropylene (PP) gowns are not only cost effective and comfortable but it provides ease in injection moulding and good dimensional stability during autoclave sterilization.

The nonwoven fabrics are spun laced, spun bond–melt blown–spun bond (SMS) and wet-laid. Many hospital garments are made of SMS–PP nonwoven composites, in which the added barrier membranes are incorporated in the middle layer to prevent the passage of blood borne pathogens or disease-causing microbes. Additional spun bond and melt blown web layers are also used for making nonwoven composite multilayer fabrics, for example, four layers with two layers of melt blown webs sandwiched between two layers of spun bond fabric layers, or five layers with three layers of melt blown webs sandwiched between two layers of spun bond fabric layers, or one layer of melt blown web sandwiched between four layers of spun bond fabric layers, or six layers generally composed of spun bond fabric, or seven layers composed of spun bond fabric. Various compositions of spun bond and melt blown materials enable the excellent combination for the filtration and absorption property of medical protective products and can provide a more breathable and comfortable barrier for the wearer.

Though these disposable surgical gowns have many advantages, cotton surgical gowns are still preferred in most hospitals at home because of cost effectiveness and reusability. The finishing treatments of the fabric are also easy to enhance the various properties.

2.2 Hospital waste

2.2.1 Status: It's something that a patient who is worried about a surgery or recovering from a trauma is unlikely to think about. But behind the scenes, plastic syringes, single-use gowns, sterile packaging, surgical instruments and much more are piling into dumpsters. While the amount of waste is difficult to quantify, a report from the Ontario Hospital Association estimates hospitals for at least 1% of non-residential are responsible landfill waste.

Hospital waste comes from areas like food, electronic and paper waste, but the biggest source is clinical care. It is found that in North America operating rooms alone generates about 20%-33% of total hospital waste. A study in US found that a single hysterectomy produced 20 pounds of waste in plastic, packaging, drapes, and so on excluding bio-waste. The problem may be getting worse – due to patient safety, cost and convenience, more and more clinical instruments and supplies are being marked as 'single use' and thrown out. However, major health organizations are keenly working towards minimizing the hospital waste.

2.2.2 Increase of throw-away medical supplies: The use of disposable items in health care is not new, for example IV tubing has been thrown out since the 1960s because it is near impossible to adequately clean it. Disposable surgical drapes have been used for last 20 years.

The shift towards disposables is still continuing with disposable [surgical] instruments being the latest in that trend. For procedures outside the OR, scissors, suturing equipment and so on used to be resterilized and wrapped in washable linen (which would be used in the procedure). Within the last few years, these instruments have all been switched over to the disposable kind. The surgical trays are now wrapped in plastic, which is also thrown out. "If a piece of equipment breaks, I now have to open a new tray and throw out all the equipment in that tray as well," doctor says. It's kind of shocking the amount of garbage that's created.

More cost-effective disposable products have also come on to the market because of advances in manufacturing technology. Manufacturers may also be erring towards more 'single use' items to avoid liability when it is not certain a product can be 100% sterilized. Disposables can also be cost-driven. They are sometimes cheaper than buying much more expensive reusable supplies that must be washed and thrown out with wear and tear.

In many other cases, however, disposables are more expensive in the long run. Yet, the low upfront costs of disposables can make them enticing for procurement managers who are tasked with saving money over a specific time period.

2.2.3. Efforts to improve hospitals' waste production: In the US, several organizations are calling for more environmental products. Earlier this year, four major health care companies and two NGOs launched the Green Health Exchange, an organization that will investigate and promote green alternatives.

The non-profit Practice Green Health is launching a free "total cost of ownership tool" that will help hospitals understand the long-term costs of disposable versus reusable products. The tool allows hospitals to enter everything from the costs they pay to dispose waste, to how often they will need to repurchase disposables, to the costs of water for sterilization. "If you look at just the price tag for the item, disposables seem far cheaper. But by capturing some of the cost to use the product over the long term, you're making a better informed purchasing decision," explains Beth Eckl, director of the Environmental Purchasing Program at Practice Greenhealth.

UHN (University Health Network, Canada) has had a green procurement policy in place since 2001, in which procurement staff investigate to see if reusable or more environmentally friendly alternatives are available. At Toronto Western Hospital, meanwhile, a neurosurgery team led by Dr. Michael Tymianski was able to save hundreds of thousands by making the switch to reusable.

2.3 Ways to minimize the impact of disposables

Some hospitals have taken aim at recycling medical supplies and packaging. UHN has a "green team" of more than 600 staff volunteers. They attend training sessions and report back to green leaders in the hospital about how recycling and other waste diversion efforts are working on the ground.

UHN also conducts waste audits once a year, in which two to three departments in the hospital are randomly targeted and housekeeping and environmental staff quantify how much recyclable material is ending up in garbage bins, and vice versa. Feedback is provided to the unit, and if poor waste management is found, the environmental team works with the unit's leaders to improve waste diversion through education sessions, new signage and recruiting green team volunteers in the unit. Then, another audit is done months later to see if there's been improvement.

In a study, it has been reported that the use of reprocess able cotton wraps to package material and linen for surgical procedures, a traditional and cheap practice, can be used safely as a microbial barrier for up to 65 reprocessing cycles. Thus, by recycling the disposable waste, we can save the environment to a great extent.

Countries which have established an institutional practice of intensive and extensive consumption of disposable items are currently being pressured to reconsider this situation. Controlling the impact of waste accumulation has become a costly problem and a major issue when the unbalanced environment is addressed. In the United States, the estimated annual cost for total waste disposal is about 3.6 billion dollars. From this total, 15% refers to hospital waste.

It has been reported that the cost of disposable surgical gowns is higher than the cost of reusable ones. In opposition, the World concern with the decrease of water reserves and the increased chemical water pollution caused by industries and laundries are undeniable.

3. Aims and objectives of present study

- To develop suitable fabric from cellulosic materials for surgical gown.
- To apply the nano cellulose coating on the surface of the fabric.
- To impart antimicrobial property to the fabric.
- To evaluate antimicrobial characteristics of the coated fabric.

Different hospitals have been visited to enhance the knowledge about the different types of surgical gowns in use, their cleaning process and their life span. It was observed that only in few cases disposable surgical gowns were used while reusable cotton surgical gowns were preferred in majority of surgical procedures. These gowns were either purchased in bulk or they were stitched on the hospital campus from the purchased fabric. The fabrics or gowns were not water repellent and having poor antimicrobial properties.

Cleaning procedure of reusable surgical gowns was observed and discussed with the staff of hospitals. In a porous steel drum about 15-20 gowns are normally loaded after properly folding them. These drums are then loaded in steam sterilization machines. Sterilization of is carried out for one hour at 15 lb pressure and 121 °C temperature. Special indicators kept with gowns having fine strips turn black, indicating proper sterilization. Damaged gowns after inspections need to be disposed off. The samples of postoperative surgical gowns have also been collected from the operation theatre (O.T.).

Disposable medical gowns are not cleaned or reused after a use. Some medical gowns can be cleaned and maintained as only reserve for a limited usage. All types of medical gowns would be rendered unusable if they are damaged on being used or contaminated during medical procedures.

If the fabric used in the manufacturing of the surgical gown has got pore size less than the size of the microbes, the microbes cannot enter the body of the healthy person through the fabric. But it might not be possible for the conventional fabric used for the gown or to modify a fabric with the particular pore size, which does not allow microbes to enter through the fabric, especially for the microbes like virus. For this purpose, a suitable fabric structure has to be developed and in extreme case a special antimicrobial coating may be applied to the fabric.

Various woven surgical gowns are either made from 100 % cotton or polyester-cotton blend. Some special gowns are also made with double-layer using linen and cotton fabrics. Due to the high costs of laundering and sterilization for reuse, most medical drapes and gowns nowadays are disposed off after single use, and nonwoven fully synthetic materials are commonly adopted for producing disposable medical garments.

However, looking at the pollution factor as mentioned above, created by synthetic fibre materials and synthetic hospital waste, such type of surgical materials should be prohibited. Instead of such synthetic disposable surgical materials, biodegradable reusable materials should be preferred i.e. surgical gowns made from eco friendly fibres should be preferred. Sometimes such materials do not prove very effective. In such cases, the materials should be given necessary treatment once or frequently to improve their efficiency.

Pure Cotton and blended cotton woven surgical gowns are in use since long. As the fabric of these gowns is produced by weaving staple yarns, there is a problem of lint generation from such gowns, during surgery. Such lint may carry microorganisms, which may infect the patient. It has been reported that in case of nonwoven fabrics, linting is very low.

In the present work, the cotton woven fabrics and viscose rich viscose-polyester blended nonwoven hydro-entangled fabrics have been treated with cellulosic nano particles. These fabrics have been evaluated for application in surgical gowns. The experiment steps of the processes are briefly mentioned in section 3.1.

3.1 Production of nano cellulose particles using laboratory set up.

3.2 Application of nano cellulose to fabrics with different concentrations of nano cellulose and different concentrations of Polyester cross-linking agent in padding mangle.

3.3 Drying and heat setting of fabric samples in conditioning oven.

3.4 Testing and evolution of treated samples.

3.5 Applying antimicrobial agent to proven samples.

3.6 Testing of potential fabrics samples for antimicrobial characteristics.

Nano-cellulose has been produced by treating viscose rayon filaments with freshly prepared solution of sodium zincate. In this study, suspensions of nano crystals were prepared from waste viscose rayon fibres. The waste viscose rayon fibres were ground to smaller than 20 mesh powder. Ground viscose rayon fibre powder was mixed with sodium zincate in a ratio of 1:9 (g/ml). A reaction temperature of 50°C was maintained for the diffusion of sodium zincate into the amorphous region of the fibres resulting in a subsequent cleavage of the glycosidic bonds. After 1 hour the particles were neutralized by glacial acetic acid solution. The suspension was washed and further filtered by Whatman No.1 filter paper. The colloidal suspension was evaporated and converted in powder form. The powder was washed with distilled water and dried.

The nano cellulose was applied to fabric samples with their different concentrations and different concentrations of Polyester cross linking agent on padding mangle. Different liquors of different concentrations of nano cellulose and cross linking agents were produced to treat the fabric samples. These liquors were prepared using distilled water. It was heated at 50 °C temperature first. Then nano cellulose power was added with constant stirring as per the concentration required. Then cross linking agent was added as per the requirement in the bath. The process timing was of 30 minutes.

Then this liquor was taken to Padding Mangle. Cotton and viscose fabric samples were treated with the prepared liquors at room temperature with different roller pressures of padding mangle. After the application of liquor on samples with Padding Mangle, the samples were collected. They were then placed in conditioning oven, set at 80 °C temperature. Then these samples were cured in oven for 3 minutes at 115 °C temperature.

The cured samples were then tested as mentioned below.

Testing of samples

The fabric samples were tested for percentage increase in weight, air permeability, water repellence, tensile strength and stiffness.

Selected/proven samples were then treated with neem seed oil solution produced in distilled water to improve antimicrobial property of the fabric samples. These samples were then tested for antimicrobial property.

4. Conclusion

Treatments given to the fabric samples with neem seed oil and nano cellulose enhanced the properties of the fabric particularly antimicrobial property and water repellence. The fabric samples considered for this work were pure cotton woven and viscose rich viscose polyester Hydroentangled nonwoven. These fabrics can be considered to design reusable surgical gowns. As nonwoven fabrics have the least tendency to lint from the fabric, viscose rich viscose polyester plain Hydroentangled nonwoven fabric can be used to produce better surgical gowns than traditional cotton reusable surgical gowns.

Reusable cellulosic gowns are preferred over synthetic disposable gowns because of their cost effectiveness and easy treatments with environment friendly materials to enhance their performance.

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