Performance of Ecofriendly Nano Coated Suture

Dr Hireni Mankodi, Japan Trivadi

Abstract —The scope of meditech embraces all textile materials used in health and hygiene applications in both consumer and medical markets. Textile products are used in medical and healthcare sector in various forms. The complexity of applications has increased with research and developments in the area of medical textiles. The Aloe-vera coating on suture material would expedite the healing; hence tissue reaction can be controlled by standardizing such process. The Aloe-vera gel coating used for suture application and performance of coating and change in properties of different Suture has been analyzed. In this project the Braided Polyester Suture is taken to standardize the process and comparative analysis has been done for coating efficiency and performance offered by different samples of PP, PET, Nylon, Viscose and Bamboo Yarns. It is also possible to use other natural finish like Neem, Turmeric etc for Surgical Suture.

Index Terms—Meditech, Sutures, Non absorbent, Antimicrobial, Alo vera, Braided, Silver nano coating , Knot strength

1 INTRODUCTION

THE increasing global competition in developing advanced textile medical products has created many challenges for textile researchers and industrialists. The rapid growth in medical textiles and their end-uses has evolved many opportunities for the application of innovative functional finishes. There are increasing concerns relating to the antibacterial textiles produced by using synthetic antibacterial agents. In view of the above and considering the environmental aspects, it is vital to carry out research by natural finish.

The present work is carried out using braided polyester yarn (A), multifilament bamboo yarn (B),PET monofilament (C), PP-monofilament (D), PA-monofilament (E), viscose staple yarn (F), polyester staple yarn (G), steel yarn (H) for standardizing the process of coating. The coating is done using Silver nano-particles synthesized using herbal extracts. Thus the process is eco-friendly as it has no harmful by-product. The microbiological studies were carried out according to AATCC (USA, U. S. Pharmacopeia Norms).

2 MATERIAL

Suture materials are characterized by various methods involving physical and mechanical properties, handling characteristics, and biological and biodegradation behavior. The specification, the size of the material used in experiment has been given in Table 1. The mechanical properties like tensile strength, breaking elongation, modulus of elasticity, and stress relaxation has been measured. The strength property is the most important mechanical characteristic of coated sutures which needs to be measured before and after coating.[7]

TABLE 1
MATERIAL DETAIL

Sr. No.	Company Name	Material	Structure	Code Name
1.	Superfil India Ltd.	Monofilament	Polypropylene (PP)	PP(M)$_{NC}$
2.	Superfil India Ltd.	Monofilament	Polyamide (Nylon-6)	PA(M) $_{NC}$
3.	Superfil India Ltd.	Monofilament	Polyester (PET)	PET(M) $_{NC}$
4.	Spinning King	Multifilament	Bamboo	B(MF) $_{NC}$
5.	Bekaert	Multifilament	Stainless Steel (Bekitex)	SS(MF) $_{NC}$
6.	Zenith Fibers Ltd.	Spun	Polypropylene (PP)	PP(S) $_{NC}$
7.	Mac Healds Ltd.	Braided	Polyester(PET)	PET(B) $_{NC}$
8.	Birla Cellulose	Spun	Viscose (Micro modal)	V(S)$_{NC}$

3 METHDOLOGY

3.1 Selection of Coating Material

The coating material used can be of organic or inorganic type (refer Fig. 1). Generally the inorganic coating is used in which coating by silver particles is very famous and widely used process.

- *Dr Hireni Mankodi, Department of Textile Engineering, The M.S University of Baroda,Vadodar 390001 Gujarat,India. E-mail: dr.mankodi@gmail.com*
- *Japan Trivedi, Masters degree student in Textile engineering, The M.S University of Barod, Vadodar 390001 Gujarat,India*

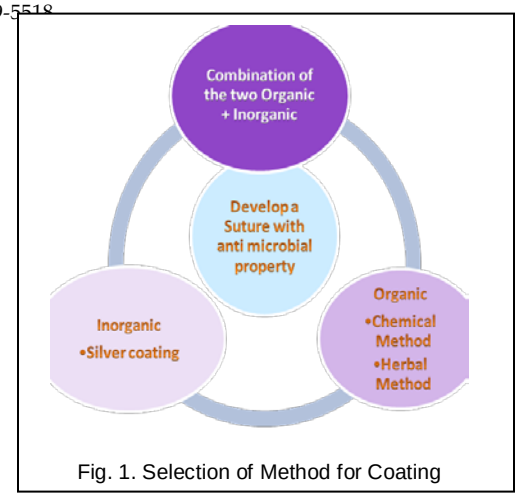

Fig. 1. Selection of Method for Coating

There are also organic methods to coat the yarn using harmful chemicals and the other method is using herbs and herbal extracts to coat the yarn which is an eco-friendly method. Looking to the environmental protocol today's world requires an eco-friendly and cost effective way to coat the yarn. Therefore in the present study the suture has been coated using silver nano particles synthesized using Aloe vera extracts. There is no need of harmful chemicals and there is no harmful by-product generated in the synthesis of silver nano particles. [8]

3.2 Process of Coating

(A) Extraction of Aloe vera Gel

Silver nano-particles have been synthesized using herbal extracts. Aloe vera leaves were washed thoroughly with distilled water. The outer green part has been removed so that the inner core can be utilized for gel extraction (Fig.2). The inner colourless core portion has been crushed in a sterilized mixer jar and filtered through whatman filter paper (Pore Size of number 40). This 5 ml of extract has been collected in a test tube, for the synthesis of silver nano particles. [3, 7, 8]

Fig. 2 Extraction of Aloe vera gel.

(B) Synthesis of Silver Nano Particles

Silver nitrate has been transformed into nano silver particles by reducing with fructose present in Aloe vera extract in aqueous solution. The 30 mgm silver nitrate has been dissolved in 100ml deionized water under constant stirring at 30^{0}C in a magnetic stirrer. Subsequently, 5 ml of Aloe vera plant extract was added and stirring was continued for 30 min at 30^{0}C. The colour change indicates the synthesis of silver nano particles. The synthesizing and coating of silver nano particles on sutures has been shown in Fig. 3. [7, 8]

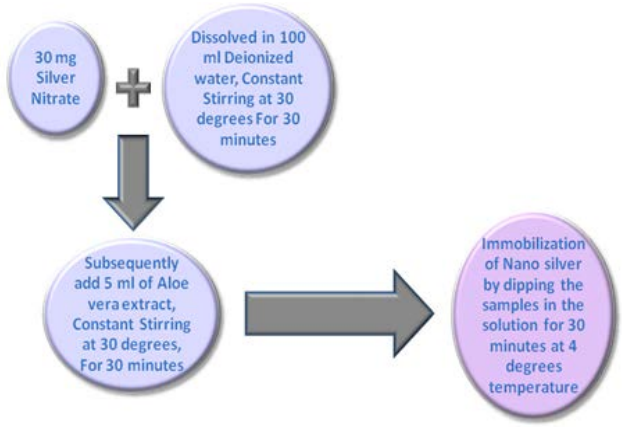

Fig. 3. Synthesis of Silver Nano particles using Aloe vera Extracts

(C) Coating on Yarn

The prepared solution consists of nano particles along with aloe vera extracts. These nano silver particles have been immobilized on by dipping the sterile yarn samples in the nano silver solution for 30 min at 4^{0}C.The constant stirring has been carried out on Magnetic Stirrer (Fig.4) with the facility to set the temperature and stirring rpm.

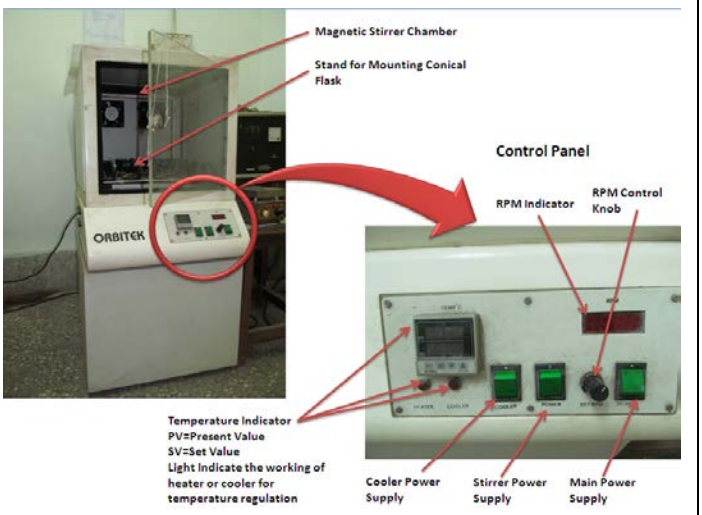

Fig. 4. Orbitek Magnetic Stirrer

(D) Pretreatment for Stabilization

It has been observed that the coating is not stable after 24 hours and the gradual degradation of the Aloe vera extracts. Hence to improve the stability of coating, the material has been pretreated with 10% chitosan (anhydrous 99% Pure) and then the material has been dipped and dried.

3.3 Coating Performance Testing

Several microbiological studies were carried out according to American Type Culture Collection (ATCC, USA, U. S. Pharmacopeia Norms) for testing the performance of the coated material. Antibacterial nature of samples was examined by zone of inhibition and viable cell count method, according to Test Method AATCC 100-1998. The antibacterial activity was checked against both Gram positive bacteria S. aureus (ATCC 25923) and Gram negative bacteria E. coli (ATCC 35218). Zone of Inhibition Colonies of S. aureus(ATCC 25923) and E. coli (ATCC 35218) obtained from an overnight culture were suspended in Nutrient Broth. Of this suspension, 200mL was spread on Muller Hinton Agar (MHA) plates to obtain a semi-confluent growth. The sutures were then placed on the inoculated medium and the plates were kept for incubation for 24 h at 37^{0}C. The inhibition zones were then observed.

(A)Sterilization

Sterilization is defined as the process where all the living microorganisms, including bacterial spores are killed. Sterilization can be achieved by physical, chemical and physiochemical means. Decontamination is the process of removal of contaminating pathogenic microorganisms from the apparatus and samples, by a process of sterilization. Three standardized sterilization methods have been used viz. ultraviolet sterilization, autoclave sterilization and heat sterilization. Ultraviolet sterilization has been used in work as shown in Fig.5.

Fig. 5 Ultraviolet sterilization

(B) Sample Preparation for Colonies Count

These plates with the samples placed on bacteria streak are placed for incubation for 24 hours at 32^{0}C temperature. Then the next day the plates are taken in laminar air flow desk and the colonies are counted that are grown around the coated and non coated yarn samples as shown in Fig. 6.

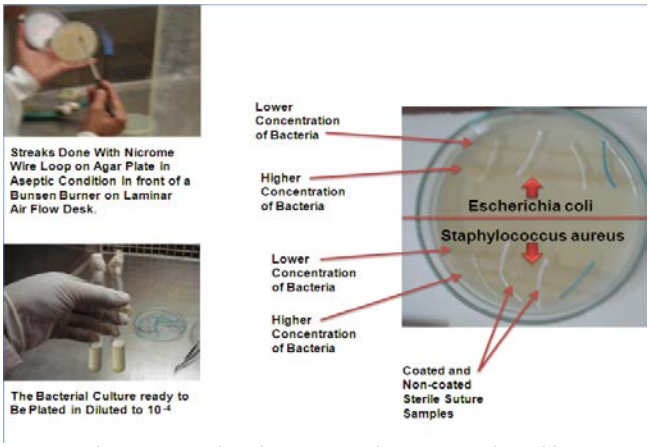

Fig. 6. Coated and Non-coated Yarn Samples with Gram Positive and Gram Negative Bacteria

3 RESULT AND DISCUSSION

Finer the suture lesser is the trauma during the surgery. The Fig. 7 indicates the direct proportionality of yarn diameter with yarn denier. The most important mechanical property of suture is the tensile strength, which should be sufficient enough to hold the wound until the wound heals and becomes strong enough to withstand the forces exerted on it during the body movement.

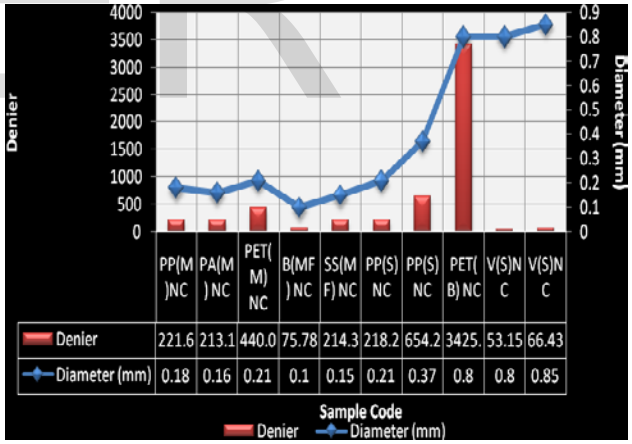

Fig. 7. Parent Yarn Diameter and Denier

The Fig 8 shows the single yarn strength values for different types of coated and non coated sutures have not been changed significantly. The sutures should not lose its tensile strength during their stay at the wound site after implantation. Some textile fibres are highly hygroscopic and their properties change notably as a function of the moisture content. Moisture content is particularly critical in the case of properties, i.e yarn tenacity, elongation, yarn evenness, imperfections, count etc.

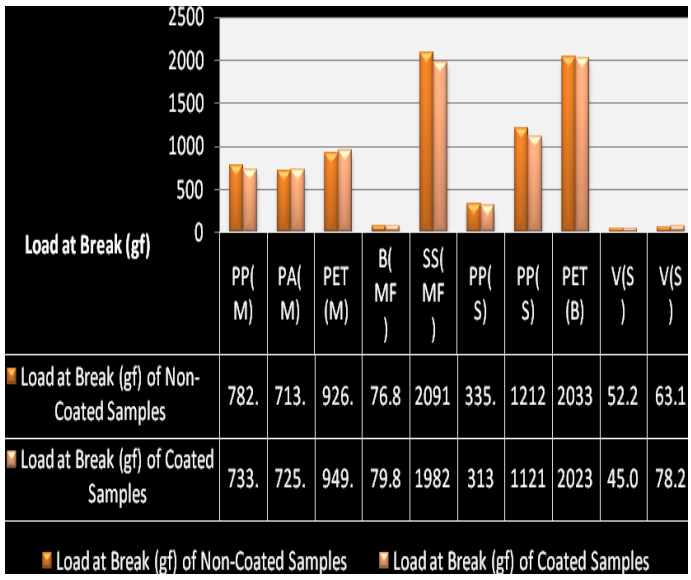

Fig. 8 Single Yarn Strength

Therefore conditioning and testing must be carried out under constant standard atmospheric conditions. The standard atmosphere for textile testing involves a temperature of 20+-2 degree C, and 65+-2% Rh. In tropical regions, maintaining a temperature of 27+-2 degree C, 65+-2%RH is legitimate. Prior to testing, the samples must be conditioned under constant standard.

The stiffness values for different yarns are shown in Fig 9.The steel yarns have the highest value, the monofilament have considerably lower values as compared to steel yarn but still on higher side while the braided yarn shows the optimum value.

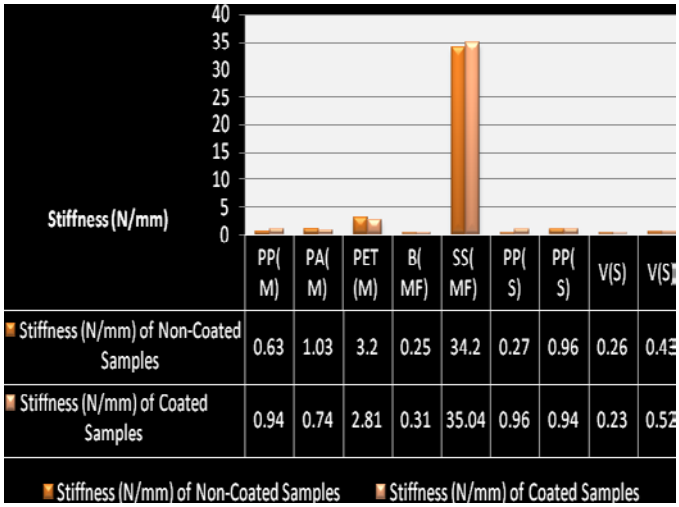

Fig. 9. Stiffness Value

The spun yarns have stiffness values within the range. Thus it can be concluded that, mono filament sutures are having more stiffness. Sutures with a braided structure were found to be generally more flexible than those of a monofilament structure, irrespective of the chemical constituents. Coated sutures exhibit slight higher stiffness than the corresponding uncoated ones. This increase in stiffness is attributable to the loss of mobility under bending force in the fibers and yarns that make up the sutures. An increase in the size of the suture significantly increased the stiffness, and the magnitude of increase depended on the chemical constituent of the suture.

Knot tensile strength is measured by the force that suture strand can withstand before it breaks when knotted. The Double Throw Knot was used which was found to be most appropriate for all the kind of materials under study. The knot security was found to be highest in the double throw knot as compared to single throw knots, especially for monofilament sutures so the former was only preferred for the present study. The knot failure or the knot insecurity is the major problem faced in any opening of wound after surgery.

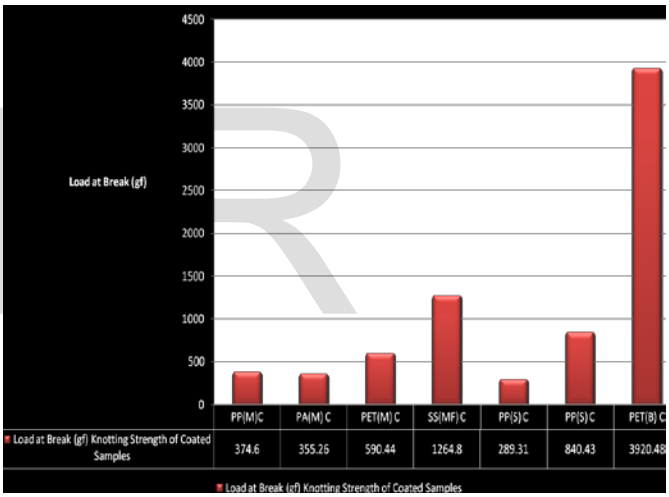

Fig. 10. Knot strength

The single yarn tensile strength of bamboo multifilament yarn and viscose spun yarn were very low and they were not considered for knot tensile strength because of their poor strength. The braided yarn exhibits the highest tensile strength while the steel yarn show considerably low as compared to braided PET suture but marginally high as compared to other sutures (Fig.10).

The knot stiffness of coated samples with respect to the non-coated samples may happen to be high in some samples because of kind of cementing happening between the fibers or filaments and even the knot security are more due to increase in the surface roughness of the yarn in case of monofilament sutures. The PP spun sutures and the Braided PET sutures are having the highest stiffness values after knotting while the steel sutures are having considerably low values as compared to the former two verities, but still steel sutures have high

stiffness values after knotting as compared to other sutures in the study

In case of sutures, capillarity is the process by, which fluid and bacteria are carried into the interstices of multifilament fibers. Capillary suture materials should not be used in contaminated or infected sites. The hygroscopic yarns prove to be in appropriate for use as they have more capillarity than the non hygroscopic yarns. There should be least capillarity in the material that is to be used for suture application. The non hygroscopic sutures show less capillarity while the hygroscopic ones show more rise in the water column as shown in Fig. 11. Capillarity also depends on the angle of contact of water made with the material of suture.

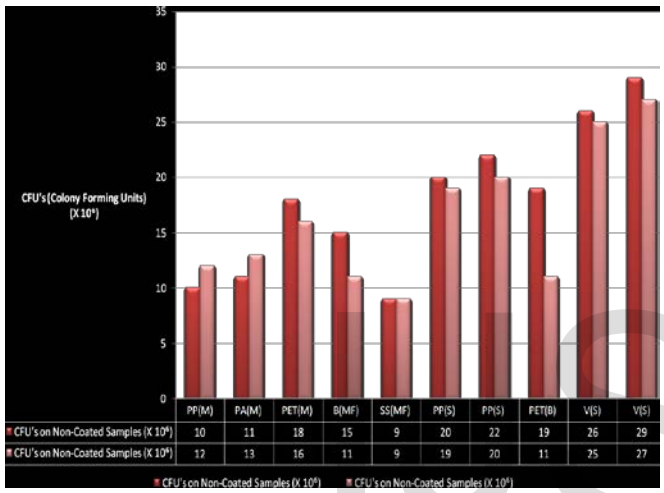

Fig 11 Capillarity for non-Coated Samples

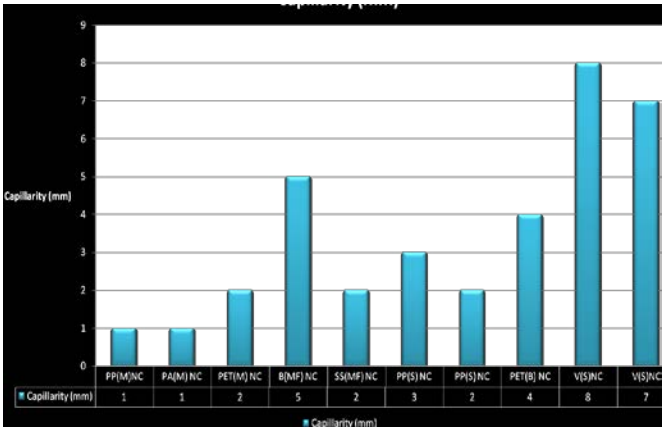

Fig 12 Coating Performance Average CFU's Counted

The coated yarn was tested for its performance by testing its resistance against bacterial growth. The CFU's (Colony Forming Units) were counted on and around the coated and non coated yarn samples. The lesser amount of bacterial colonies grown around the coated suture samples as compared to non coated suture samples indicates that there is mild antimicrobial property in the coated samples (Fig. 12), But in case of some monofilament the contradictory results are observed which might be due to increase in surface roughness due to coating which provide more room for bacterial anchorage as compared to non coated sutures which have comparatively very smooth surface.

4 CONCLUSIONS

The braided yarn give better performance strength wise to hold the trauma or surgery, instead monofilament yarns can be used where less strength is required. Multi filament yarns are less recommended as it provides more room for anchorage of the bacteria and provide good condition for the body fluids to deposit as it has more capillarity. Steel yarn is recommended and is considered to be the best alternative for all kind of surgeries but it is very rigid and so gives very poor knot security while the braided yarn gives the best results.

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