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A Study of Role of Plastics in Medicine

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ABSTRACT

Plastic items are most important accessories in medical sector, that play key role in labs and hospitals. It is evident that plastics bring many benefits and offer future technological and medical advances. Plastics play significant role in healthcare, and helped delivering safer medical services. The material should be non-toxic, effective, sterilizable & bio-compatible. Various types of polymers are used differently according to their properties. All hospital acquired plastic waste is either incinerated or recycled. More use of plastics has its own adverse effects on environment, as they're not easily degradable. There're various methods to manage this problem, like, 'Reduce', 'Reuse', 'Recycle', 'Molecular Redesign', & use of absorbable material as much as possible.

KEYWORDS : Bio-absorbable, Plastics, Polymer.

INTRODUCTION

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastic items are most important accessories in medical sector playing key role in labs and hospitals used at huge level. At present we see thousands of plastic manufactured items in our nearby hospitals, clinics, labs, medical institutions. Most of the plastic ware products are disposable or for one time use.

It is evident that plastics bring many benefits and offer future technological and medical advances. Plastics play significant role in healthcare, and helped delivering safer medical services. Plastics are so safe and non-toxic that scientists keep on inventing more and more advanced applications using plastics for improving healthcare management of tomorrow.

However, there are concerns about usage and disposal, and include accumulation of waste in landfills and in natural habitats. Around 4% of world oil production is used as a feedstock to make plastics and a similar amount is used as energy in the process [2].

There are solutions, including material reduction, design for end-of-life recyclability, increased recycling capacity, the application of green chemistry life-cycle analyses and revised risk assessment approaches. Such measures will be most effective through the combined actions of the public, industry, scientists and policy-makers.

The term "bio-absorbable" is used here in broad meaning that the polymer will eventually disappear after introduction in the body.

PLASTIC AS A MATERIAL

Perhaps the greatest technological advancements in human society have evolved through the medical professions. Over the years, plastics & technology in medical field has prolonged the average life span of an adult human by offering, diagnostic tools, in laboratories, as prosthesis, as indwelling material and comprehensive treatments. But smaller advancements — such as the materials and tools used by medical professionals on a daily basis — are often overlooked [3].

Minimum Properties of Plastics Used As Bio Materials [1].

1. Non-toxic (Bio Safe)
Non-pyrogenic, Non-hemolytic, chronically non-inflammative, Non-allergenic, Non-carcinogenic, Non-teratogenic, etc.

2. Effective
Functionality, Performance, Durability, etc.

3. Sterilizable
Ethylene oxide, γ-Irradiation, Electron beams, Autoclave, Dry heating, etc.

4. Biocompatible
Interfacially, Mechanically, and Biologically

Bio Compatibility of Plastics: A material will be considered biocompatible (in a specific application) if it allows the body to function without any complications such as allergic reactions or other adverse side effects.

ISO 10993/EN 30993is used for Biological Evaluation of Medical Devices [1].

Safety

- The use of plastics revolutionized the field of medicine by making procedures & tests safer& simpler. For example, all of the equipment that surrounds a Magnetic Resonance Imaging Machine is created out of plastic to guard against difficulty of not being able to use metal around it. Even tools utilized to install the Magnetic Resonance Imaging Machine are fabricated out of plastic [4].
- Almost every part used of plastics in a patient, is disposable, single

use. So it brings unmatched height of safety to the patients, at the acceptable costs.

Cost Reduction

- Plastics have contributed to a reduction in medical costs, infectious disease and pain management.
- The cost of producing a plastic tool is much less than a stainless steel model, allowing a hospital or doctor's office to adjust their budget for other technologies such as digital imaging software.

Implants & Prosthesis

- Ultra high density polymers are used to create new and improved artificial limbs have reduced morbidity due to disability [6].
- Today's artificial knees and hips rely on ultra high density plastics to provide people with pain free movement and trouble-free joints.
- Various Implants; either temporary or permanent; are helpful in treating the patients, and occasionally life-saving. They're also safe for patients in terms of infection.

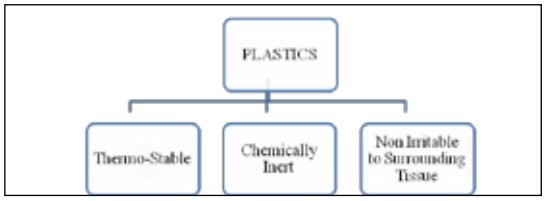
Preventing Infection

- Plastic disposable delivery devices have succeeded in reducing the risk of infection to patients by sterile plastic packaging and plastic medical disposables in particular have contributed to keeping the rates low.

Routine Use:

- Even for something as simple and common place as spectacles, plastics have improved people's lives.
- The incorporation of plastics into the frames and contact lenses of eyewear has helped to reduce their weight and increase overall safety.
- Soft and pliable plastics are used for surgical gloves that help maintain the sterile atmosphere of hospitals' operating room.

Figure 1: Various Desirable Characteristics



Types of Plastics used in Medicine

This is only a small list of the possible applications of plastics in medical devices.

Table 1: Various Bio- Compatible Polymers & its uses.

Polymer	Use
Poly-vinyl chloride	• Biocompatible in both the plasticized and unplasticized grades. • Blood tubing. • Blood bags.
Poly-tetra-fluoro-ethylene	• Tubing (single and multi-lumen). • Endoscopes, cannulas. • Radio lucent linings of Catheter. • Syntheticblood vessels (arterial grafts). • Patches for soft tissue regeneration. • Surgical sutures. • Reconstructive and cosmetic facial surgery.
Poly-ether Sulfone	• Tubing (single and multi-lumen). • Catheters.
Poly-ethylene	• Implantable Products • Surgical cables& orthopedic sutures • Artificial tendons.
Poly-urethane	• Breathable wound dressing films
Poly-etherimide	• Surgical Skin Staplers
Poly-carbonate	• Medical containers with glass transparency. • Check valves. • tubing connectors
Poly-ether-ether-ketone	• Dentistry products • Rigid tubings
Poly Sulfone	• Artificial heart components • Heart valves
Poly-Propylene	• Heart valve structures, Suture Material, Mesh.

Table No. 2: Various Functions of Plastics.

Function	Purpose	Examples
Bonding	Suturing	Vascular and intestinal anastomosis
	Fixation	Fractured bone fixation
	Adhesion	Surgical adhesion
Closure	Covering	Wound cover, Local Hemostasis
	Occlusion	Vascular embolization
Separation	Isolation	Organ protection
	Contact inhibition	Adhesion prevention
Scaffold	Cellular proliferation	Skin reconstruction, Blood vessel reconstruction
	Tissue guide	Nerve reunion
Capsulation	Controlled drug delivery	Sustained drug release

Child Safety:

- Today, almost all types of pharmaceutical packaging features tamper-proof seals. The introduction of child-resistant caps keeps potentially harmful medicine out of the hands of children [7].
- Plastic cord clamps, which are disposable, have reduced rates of neonatal sepsis.

Hemostasis:

- Polymers are used for hemostasis, sealing, and adhesion to tissues.
- The biomaterials used to prepare such liquid products include fibrinogen, 2-cyanoacrylates, and a gelatin/resorcinol/formaldehyde mixture.
- Immediately after application of a liquid to defective tissue where hemostasis, sealing, or adhesion is needed, the liquid sets to a gel and covers the defect to stop bleeding, seal a hole, or adhere two separated tissues [19].

Laboratory & Plastics:

- Plastics address healthcare needs both large and small labs, from petri dishes in the lab, to the housing of large diagnostic medical machinery.
- Micro pipettes, ELIZA DOT Test also utilize the plastic bricks [8].
- Additional cost savings can come from the use of medical equipment and care that can now be provided at home, as portable, effective and simple medical devices are being designed for use by the patient in a home setting.

Suturing:

Two types of suture materials are available; Absorbable & non-absorbable. In both types, the polymers are available providing tensile strength. The largest and longest use of bio-absorbable polymers is for suturing [9].

■ **Absorbable**

- Synthetic: 'VICRYL'. They include polyglycolide, which is still the largest in volume production, together with a glycolide-L-lactide (90:10) copolymer [1, 5].
- Non Synthetic: 'CAT-GUT'. Collagen fibers obtained from animal intestines have been long used as absorbable suture after chromium treatment [10].

■ **Non Absorbable**

- Synthetic: Proline [11] (poly-propylene).

Use for tissue engineering

Tissue engineering is an emerging technology to create biological tissues for replacements of defective or lost tissues using cells and cell growth factors [4].Bio-absorbable polymers are required to fabricate scaffolds for cell proliferation and differentiation which result in tissue regeneration or construction. Tissue engineering can provide biological tissues and organs that are more excellent in both bio-functionality and bio-compatibility. Currently, the polymers used for scaffolding include collagen, glycolide-lactide co-polymers, other co-polymers of lactide, and cross-linked polysaccharides.

Bio-medical Applications

A variety of polymers have been used for medical care including preventive medicine, clinical inspections, and surgical treatments of diseases [4, 12-15]. Among the polymers employed for such medical purposes, typical applications of biomaterials in medicine are for

- Disposable products
- Syringe
- Blood bag
- Urinary Catheters
- Ryle's tube
- Hand Gloves
- Universal Precaution Kit
- Core of Capsule
- Infusion Sets
- Intravenous Catheters
- Intra-thecal Catheters
- Three way connector
- Ventilator Circuits
- Endo-tracheal Tubes
- Infant feeding tube.



Figure 2: Central Venous Line

- Materials supporting surgical operation
- Sutures
- Absorbable
- Synthetic
- Non Synthetic
- Non Absorbable
- Synthetic
- Non Synthetic



Figure 3: Artificial Limb Implant

- Adhesives & Sealants like Cyano-Acrylate glue.
- Prostheses or Implants for tissue replacements Temporary or Permanent
- Intraocular lens.
- Dental implant.
- Breast implant.
- Proline Mesh for Hernioplasty.
- Double J Stent
- Sengston Blackmoore Tube
- Ureteric Catheter
- Cardiac Valves
- Kehr's T-tube.

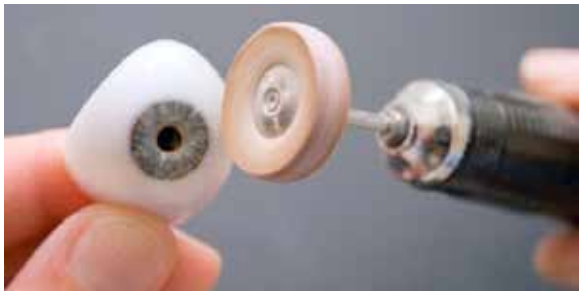


Figure 4: Artificial Cornea

- Intra Cavitary Drains.
- Intra Articular UHDP implants



Figure 5: External Hearing Aid

- Artificial organs for temporary or permanent assist
- Artificial kidney
- Artificial heart
- Vascular graft
- Pace maker
- Hearing aid
- Contact lenses
- Spectacles.

Fate of the Plastics (Degradation):

Plastics used in medical field have various fates. Polymer degradation takes place mostly through separation of the main chains or side-chains of polymer molecules, induced by their thermal activation, oxidation, photolysis, radiolysis, or hydrolysis. Some polymers undergo degradation in biological environments when living cells or microorganisms are present around the polymers. Such environments include soils, seas, rivers, and lakes on the earth as well as the body of human beings and animals.

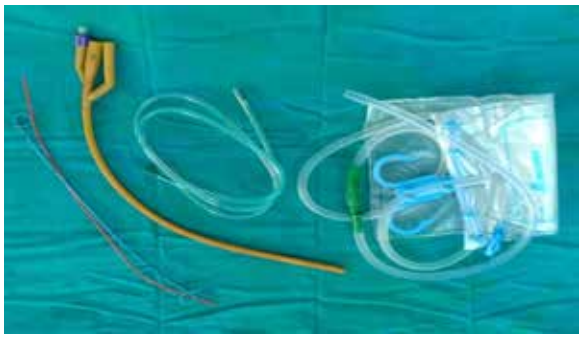


Figure 6: Uses of Plastics in O.T. in Human;
A - DJ Stent; B– Catheter; C– Ryle's Tube; D– Abdominal Drain

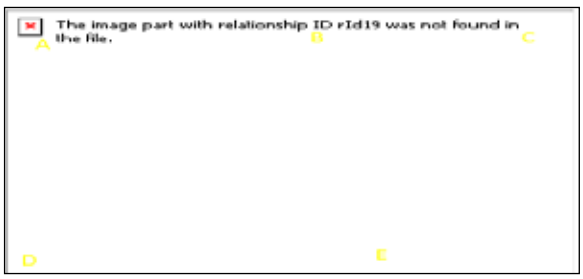




Figure 8: Plastics & Eye;
a: Contact Lens, b: Intra Ocular Lens

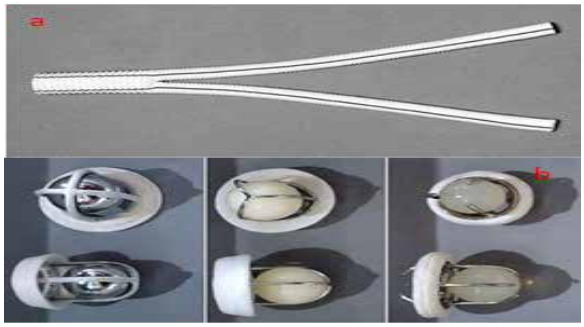


Figure 9: Plastics & Cardiac Surgery;
a: Dacron Graft, b: Cardiac Valves

Various indwelling polymers remain as it is inside the human body, like
- Poly-propyline (proline) remains inside the body till life time and induces fibrosis.
- Absorbable materials like 'Vicryl' and 'Cat-gut' have their own absorption according to their property.
- Plastics used outside the human body are mostly incinerated or recycled; depending upon its body fluid's contacts and contamination.

Table 3: Representative synthetic bio absorbable polymers currently used for medical application[20].

Polymers Structure	Degradation rate in Human Body	Medical application
Poly(glycolide)	100% in 2–3 months	Suture, Soft issue anaplerosis
Poly(glycolic acid-co-L-lactic acid)	100% in 50–100 days	Suture, Fracture fixation, Oral implant, Drug delivery microsphere
Poly(L-lactide)	50% in 1–2 years	Fracture fixation, Ligament augmentation
Poly(L-lactic acid-co-e-caprolactone) Amorphous	100% in 3–12 months	Suture, Dural substitute
Poly(e-caprolactone)	50% in 4 years	Contraceptive delivery implant
Poly(p-dioxanone)	100% in 30 weeks	Suture, Fracture fixation
Poly(orthoester) Amorphous 100–150	60% in 50 weeks	Contraceptive delivery implant

DISCUSSION

There are various pros & cons of using plastics in medicine.

Advantages:

- Less chance of person-to-person spread of infection.
- Easily available.
- Safe.
- Bio-Compatible.
- Chemically Inert.
- Thermo-stable.
- Economical.
- Easily sterilized.

Disadvantages:

- Tissue Reaction.
- Allergy.
- Inflammation at foreign body local site
- Indwelling foreign body plastics more prone to hospital acquired infection.
- Difficulties in Waste management.

Early medical instruments were made of metals prone to rusting and inaccuracy, & contributed to infections when used between patients. Even today, some medical instruments are made of stainless steel. Though the metal is easier to sterilize, surgical steel is still not flexible and has limitations in size and weight.

Plastics, however, can be molded to any shape or size. They are easily sterilized and more flexible than metal, allowing for greater maneuverability and precision.

But the use of plastics in the medical field is not confined solely to medical tools. An increasing amount of hospital devices are now being manufactured from plastic, enabling maximum cleanliness and efficiency.

Waste Management Solutions [16-18]

As we all know, plastics are not easily degradable, they impose very serious problems over environment that cannot be under-estimated.

All plastic waste from hospital is either incinerated or recycled. From a waste management perspective, the five R's
- Reduce
- Reuse (Only where feasible; not at the cost of safety)
- Recycle
- Energy Recovery.
- Molecular Redesign, as an emerging and potentially very important strategy.

We need to consider the five R's in combination with each other and together. There are opportunities to 'reduce' usage of disposable material sensibly. There are also some opportunities to 'reuse' plastics, for example, in the packaging of medicines and other things from recycled plastics. However, there is limited potential for reuse of retail packaging because of the safety issue is also involved; which, in any case, must be given priority. Some of the energy content of plastics can be 'recovered' by incineration. Newer techniques in recycling of plastics and redesign and production of newer, safer, easily & quickly recyclable molecules should be developed as early as possible.

These measures, along with use of absorbable material, wherever possible should be used.

Use of Bio Absorbable & Bio Degradable polymers:

In a strict sense, such polymers that require enzymes of microorganisms for hydrolytic or oxidative degradation are regarded as biodegradable polymers. Generally, such a polymer that loses its weight over time in the living body is called an absorbable. To avoid this confusion, some people insist that the term "biodegradable" should be used only for such ecological polymers that have been developed aiming at the protection of earth environments from plastic wastes, while the polymers applied for medical purposes by implanting in the human body should not be called biodegradable but bio absorbable.

These approaches have benefits compared with disposal to landfill since some of the energy content of plastics is recovered. However, energy recovery does not reduce the demand for raw material used in plastic production, hence it is considered less energy efficient than product recovery via recycling.

Recently, bio-absorbable medical polymers have attracted much attention. There are at least two reasons for this new trend.

- One is the difficulty in developing such biocompatible materials that do not evoke any significant foreign-body reactions from the living body. At present we can produce biomaterials that are biocompatible, if the contact duration of biomaterials with the living body is as short as several hours, days, or weeks. However, the science and technology of biomaterials have not yet reached such a high level that allows us to fabricate biocompatible implants for permanent use. On the contrary, bio-absorbable polymers do not require such excellent bio-compatibility since they do not stay in our body for a long term but disappear without leaving any trace of foreign materials.
- The other reason for bio-absorbable polymers attracting much attention is that nobody will want to carry foreign materials in the body as long-term implants, because one cannot deny a risk of infection eventually caused by the implants.

So, usage of the bio absorbable products in human being & bio degradable products in packaging must be practiced.

Although absorbable polymers seem very promising in medical applications, these kinds of polymers currently do not enjoy large clinical uses, because there is a great concern on bio-absorbable medical polymers. This concern is the toxicity of biodegradation by-products, since the causes of toxicity of biomaterials are mostly due to low-molecular-weight compounds that have leached from the biomaterials into the body of patients.

CONCLUSION

Lately, in the media, plastics have been getting a bad reputation. Due in part to the fact that plastic is not bio-degradable. But it is not likely that anything can replace plastic in the field of medicine, or that its use will be reduced in the very near future. The medical industry has been greatly improved due to the incorporation of plastics across a whole range of uses in all fields of medicine. The medical industry has become safer as a result of the introduction of plastics.

But, at the same time, we need to consider the five R's in combination with each other and together to decrease the environmental pollution from plastics

Ultimately the patients, and that's you and me, benefit the most from the use of plastics in medicine.

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