From Non-Absorbable to Absorbable Polymers

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Introduction:

Non-absorbable polymers including nylon, polyethylene terephthalate (PET), poly (1,4-butylene terephthalate) (PBT) and polyurethanes are used extensively for making fibers and molding articles. Some of these are used in a variety of biomedical applications such as non-absorbable surgical sutures, films, short-term and long-term medical devices and are considered safe and biocompatible. Unfortunately, these polymers are non-absorbable and, therefore, cannot be used in those medical applications where absorbability is a pre-requisite.

The widespread availability and applications of these non-absorbable polymers makes it imperative to enhance their native value, for example, by transforming them into absorbable polymers through chemistry. The resulting polymers will have physical properties of non-absorbable polymers and controlled degradation profile of an absorbable polymer.

Motivations to incorporate biodegradability into the backbone chain of a non-absorbable polymer led us towards the development of absorbable nylon, poly(ethyleneterephthalate) and polyurethanes. These absorbable polymers were prepared from their precursor monomers wherein these precursor monomers were functionalized with safe and biocompatible molecules including L-lactic acid, glycolic acid, open chain of p-dioxanone and caprolactone, prior to polymerization.

Key aspects of these polymers along with their in vitro hydrolytic degradation profiles will be discussed.

Results and Discussion:

Absorbable Nylon: Absorbable Nylon with varying hydrolytic degradation profiles were prepared from adipic acid and hexamethylenediamine monomers functionalized with varying safe and biocompatible molecules including glycolic acid, lactic acid, open chain form of caprolactone and p-dioxanone. As shown in figure 1, absorbable nylon was prepared from functionalized hexamethylene diamine and functionalized adipic acid.

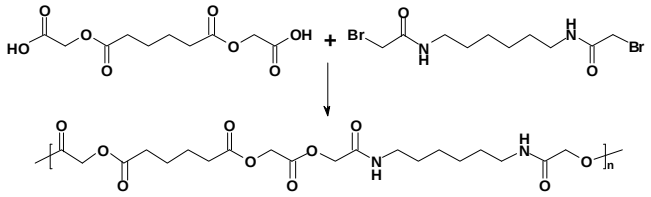

Figure 1. Absorbable Nylon prepared from glycolic acid functionalized adipic acid and functionalized hexamethylenediamine

Absorbable Polyurethanes: Absorbable polyurethanes were prepared from highly reactive isocyanates that are similar to MDI but are absorbable and have tunable hydrolytic degradation profiles. What distinguishes our isocyanates from the commonly used isocyanate, MDI, is the presence of a degradable linkage bridging the aromatic rings in figure 2(b) instead of the non-degradable methylene group as shown in figure 2 (a). Furthermore, the degradable linkage in our isocyanates is derived from safe and biocompatible glycolic acid, lactic acid, caprolactone, p-dioxanone and diols such as ethylene glycol. These monomers are the key components of majority of absorbable polymers used to make commercial biomedical devices.

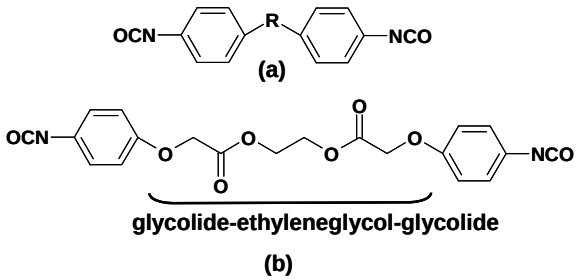

Figure 2. (a) MDI, Methylene diphenyl isocyanate, R is a CH_2 group (b) Absorbable aromatic diisocyanate similar to MDI derived from safe and bicompatible glycolic acid and ethylene glycol monomers.

Polyurethanes derived from these novel isocyanates and chain extender diols are expected not only be absorbable but also possess for the first time degradable hard segments. Furthermore, the hydrolytic degradation rate of these polyurethanes can be controlled by deriving the degradable hard segment from safe and biocompatible lactic acid, p-dioxanone and caprolactone monomers in the linker bridging the aromatic rings in the hard segment.

Conclusions: We have developed absorbable nylon, PET and polyurethanes that have combined attributes of non-absorbable and absorbable polymers. These polymers are expected to find use in a variety of biomedical applications including controlled drug delivery, wound care applications, adhesion prevention, tissue adhesives and sealants, medical devices, medical device coatings and tissue engineering.

References:

(1) Bezwada, Rao S., US Patent Publication No. 20060173065
(2) Bezwada, Rao S., US Patent Publication No. 20060188547
(3) Bezwada, Rao S., US Patent Publication No. 20070141113