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Polyurethanes and Usage Areas

By Gülay Baysal & Esra Kasapbası
Istanbul Aydin University

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POLYURETHANESANDUSAGEAREAS

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Polyurethanes and Usage Areas

Gülay Baysal [α] & Esra Kasapbası [σ]

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I. Introduction

The repeating unit in PUs is the urethane linkage produced from the reaction of an isocyanate (–N C O) with an alcohol (–OH). The basic reaction of urethane formation is shown in Fig 1. Although PUs contain repeating urethane groups, othermoieties such as urea, ester, ether and aromatic mayalso be present in the structure [1].

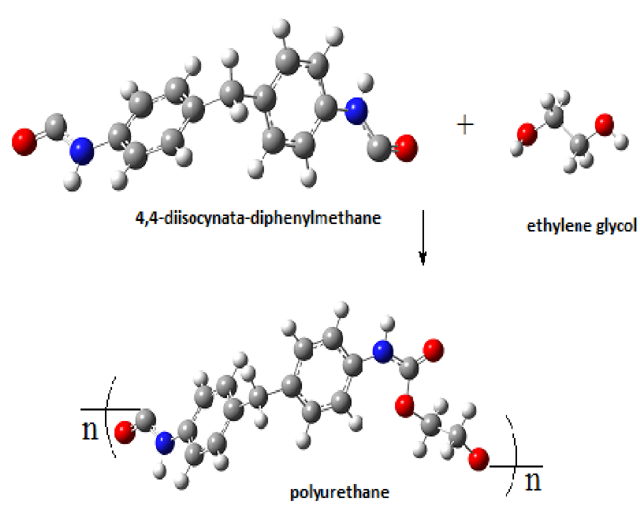


Figure 1: Molecule formula forpolyurethane synthesis

Author α: Food Engineering,Engineering Faculty, Istanbul Aydin University, Istanbul, Turkey. e-mail: gulaybaysal@aydin.edu.tr
Author σ: Molecular Biology and Genetic, Science Faculty, Halic University, Istanbul, Turkey. e-mail: esrakasapbasi@halic.edu.tr

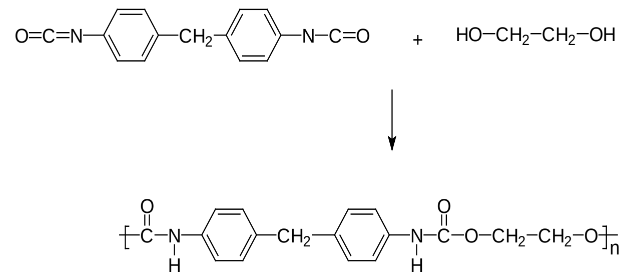
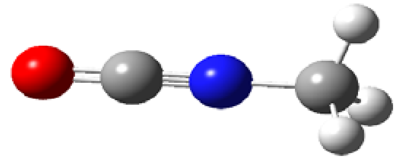


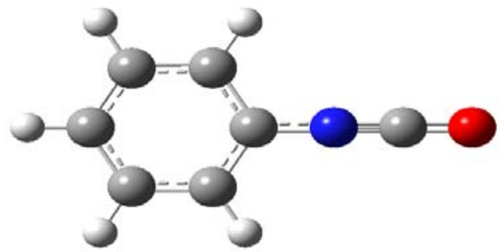
Figure 2: Structure formula of polyurethane synthesis

The flexibility available in the selection of raw material components such as di-/tri-isocyanates, polyols, as well as chain extenders have made it possible to custom tailor the properties of PUs to a large extent. The most commonly used polyols are polyethers, polyester polyols or acrylic polyols. On the other hand, methylene diphenyl diisocyanate (MDI), hydrogenated MDI (H12MDI), toluene diisocyanate (TDI), isophorone diisocyanate (IPDI), xylene diisocyanate (XDI), and 1,5-naphthalene diisocyanate (NDI) are widely used diisocyanates in PU formulations.

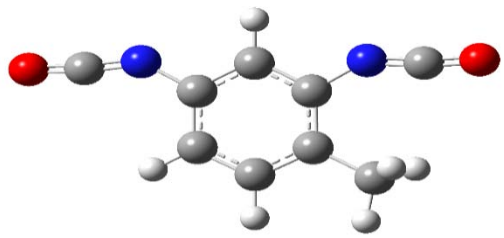
Isocyanates used to manufacture commercial polyurethanes are usually aromatic. The type of isocyanate directly affects the properties, curing system and processing parameters of the final polyurethane product. The most significant feature of an isocyanate is its functionality, i.e. the number of isocyanate (-NCO) groups in each molecule. Isocyanates appropriate for producing cross-linked polyurethanes should have more than 2 functional groups. When a difunctional isocyanate (diisocyanate) reacts with a difunctional polyol, a long-chain, linear polyurethane molecule forms.



methyl isocynata



phenyl isocynata

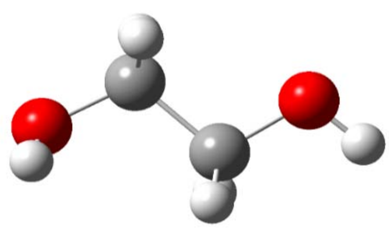


2,4- toluene diisocynata

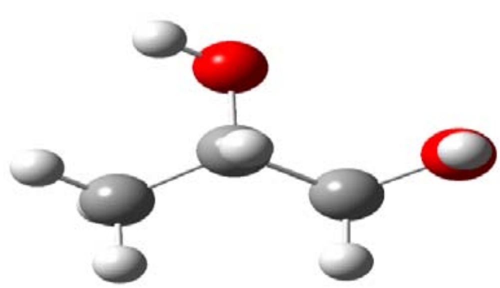
Figure 3: Molecular structures of some isocynates

Two types of polyol are mainly used in the polyurethane industry: the polyether type and the polyester type. Polyester polyols are obtained from the condensation reaction of a diol (i.e. ethylene glycol) and a dicarboxylic acid (i.e. adipic acid).

Polyether diols usually have a low molecular weight and are obtained from propylene oxide and ethylene oxide. The basic constituent in such polyols is propylene oxide; and ethylene oxide is used in small quantities to modify the polyol's properties. Poly (ethylene adipate) is a typical polyester polyol, while poly (tetramethylene ether) glycol is a typical polyether polyol.



polyethylene glycol



polypropylene glycol

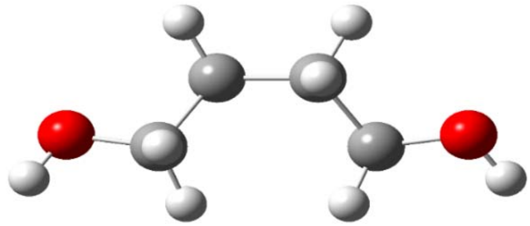


Figure 4: Molecular structures of some polyalcohols

PUs are available as both thermoplastics and thermosets. Thermoplastic Pus (TPUs) are linear, segmented copolymers consisting of alternating hard segments (HSs) and soft segments (SSs).

HSs, comprised of diisocyanate and short chain extender (CE) molecules such as diols or diamines, are rigid and highly polar. HSs have high inter-chain interaction due to hydrogen bonding between the urethane/urea groups. The hydrogen bonding associations within the HSs in TPUs act as a reinforcing filler for the softmatrix. On the other hand, SSs, formed fromlinear long-chain diols or polyols, are flexible and weakly polar. The polyol component of the Pus can be a polyfunctional polyether, polyethylene glycol (PEG), polypropylene glycol (PPG), polytetramethylene glycol (PTMG)], polyester polyol, acrylic polyol, polycarbonate polyol, castor oil or a mixture of these. Phase separation occurs in TPUs because of the thermodynamic immiscibilityor incompatibility between the hard and soft phase [2,3].

Polyurethanes are amber and can be easily stretched, which is a characteristic similar to elastomers. They are resistant to scratches, tears and impacts. They are tight but have excellent impact absorption properties. They are resistant to organic solvents, acids and greases.

Thermoset polyurethanes are available in various forms, such as soft foam and hard foam. Soft foams are used in the production of beds, quilts and packaging materials, while hard foams are used as isolation materials. Thermoplastic polyurethanes are made of linear and highly crystalline molecules. They are used to produce wear-resistant materials; for instance, a footbed, fender, door panel, vehicle exterior tire, seal, car bumper or synthetic leather etc.

Figure 5: Application example of polyurethane foam

Thermoplastic polyurethanes (TPUs) are linear block copolymers characterized by hard and soft segments. The hard segments (HS) are made from diisocyanate while the soft segments (SS) consist of long flexible polyether or polyester chains which interconnect two hard segments. In particular, the hard segments act as multifunctional tie points working as both physical crosslinks and reinforcing fillers, while the soft segments primarily influence the elastic properties of TPU. Thanks to their particular chemical structure, these materials have various interesting properties such as: wide range of service temperatures and harness options, excellent tear and abrasion resistance, good resistance to nonpolar solvents, high compression and tensile strength. These properties make TPUs suitable for several products such as automotive components, medical devices, food processing equipments, and so on. Despite these appealing properties, enough space is still left to the research in order to even improve and develop the fields of application for TPUs [4].

II. Usage Areas of Polyurethanes

PUs have found extensive use in numerous commercialapplications such as coatings, foams, adhesives, sealants, synthetic leathers, membranes, elastomers as well as in many biomedical applications PUs are one of the most useful commercial classes of polymers which are widely used in both industry and in everyday life[3].

Polyurethanes (PUs) are widely used as elastomers, foams, synthetic leathers, membranes, fibers, catheters, tissue scaffolds, coatings, adhesives and sealants owing to their excellent physical and bio-compatible properties. With rapid development of the information technology industry, e.g., advanced integrated chips and organic light- emitting display (OLED) devices, PUs have attracted much attention as electronic packaging materials because of their high flexibility which can reduce thermal stresses caused by thermal shock. But their low thermal conductivity is a majör drawback, since the heat generated in these devices cannot be easily removed. So, high intrinsic thermal conductive solid fillers, e.g., metal powders, ceramic particles, carbon black, carbon fiberand silica, have been incorporated in PUs. Even so, these composites either cannot meet the stringent requirements for electrical insulation or high filler loading is needed to achieve the necessary thermal conductivity at the expense of processing difficulties. Thus, the major challenge is to overcome the apparent conflict between the requirements of high thermal conductivity and electrical insulation in electronic packages [5].

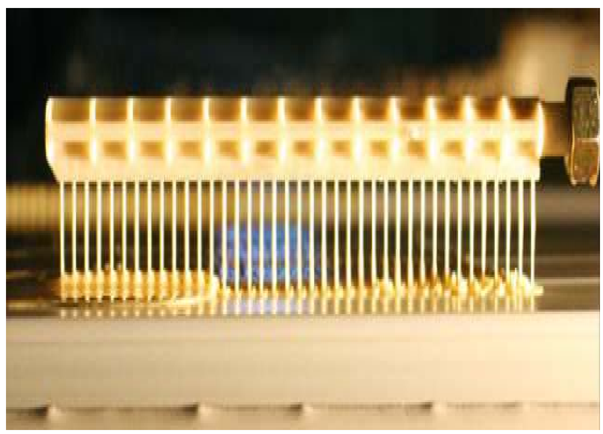


Figure 6: Thermal conductivite application of polyurethane

Polyurethane a good heat insulation material has been used in structures and buildings since the 1950s. Polyurethane-filled sandwich panels are extensively preferred by investors and designers around the world. Polyurethane having the best insulation value among various insulation materials used in structures provides savings of up to 40% in heating and air-conditioning applications. The use of fossil fuels constitutes 80% of CO_2 emissions worldwide. The use of polyurethane, therefore, is a rational approach to help decrease the CO_2 emissions that are mainly responsible for global warming. Investors usually expect high performance with lower costs, and the best response to such an expectation is polyurethane.

In recent years, there has been a growing demand for high-performance dielectric elastomers for various applications including electroactive materials. Dielectric elastomer actuators offer high energy density, large strain, and fast response times, makingthem very attractive for a wide variety of applications on both the macro and microscale. Thermoplastic polyurethane (TPU) elastomers are comprised of alternating soft and hard segments. They possess high elongation, moderate tensile strength and Young's modulus, and excellent abrasion and tear resistance, thus making them a promising material for electroactuation. However, the application of PU as an electroactive material has been limited due to the very high actuating electric field (typically greater than 100 MV/m) required to generate a large strain and a high strain energy density due to its low dielectric constant,which is, in fact, a characteristic of all dielectric elastomers. The high power requirement may also present a real hazard, thereby further limiting its potential application. In order toenhance the dielectric constant of TPU, various types of filler including high- dielectric-constant ceramic fillers such as montmorillonites (MMT), titania, and barium oxide have been blended with TPU. Conductive fillers such as carbon nanotubes, copper, graphene, and silver nanoparticles have also been blended with TPU [6].

The growing global concern over the environment is now encouraging the use of renewable sources of materials that do not harm nature and come from an alternative source of good economic potential. Lignocellulosic fibers fall into this category, since they originate from renewable resources, are biodegradable and recyclable, and in tropical countries these fibers can be produced in abundance, facilitating their use. In recent years, lignocellulosic fibers including banana, sisal, jute and coconut fibers have attracted the attention of many research groups that are considering their use for industrial purposes and the reinforcement of polymers. These fibers have many advantages compared to glass fibers, such as low density and low cost, and they are recyclable and biodegradable. Moreover, there is a high production of fibrous plants in tropical countries and some of them, for instance, banana, are agricultural crops. The use of banana fibers is of particular interest because they originate from agricultural waste, being extracted from the pseudostem which would be abandonedin the farming practice for natural decomposition after the harvesting of the fruits. Hence, with no additional cost input banana fibers can be obtained for the reinforcement of thermoplastic and thermoset matrices. The use of polyurethane (PU) as a polymeric matrix isan excellent alternative due to the high compatibility with banana fibers. Additional isocyanate groups of polyurethane can react with the hydroxyl groups on the banana fiber surface to produce a cross-link, improving the interfacial adhesion between the fiber and the matrix. Additionally, polyurethane can be produced through the reaction of an isocyanate and polyol synthesized from vegetable oils such as castor oil,soybean oil and passion fruit oil [7].

The use of metal nanoparticles for water disinfection is relatively new. Because of their high reactivity due to the large surface to volume ratio nanoparticles are expected to play a crucial role in water purification when water becomes an important commodity. Several investigations have been carried out on the bactericidal effect of nanoparticles and their applications in the plastics, health, textile, and paint industry. Pesticide removal from drinking water with the help of nanoparticles was reported in our previous work. The aim of this study is to demonstrate the antibacterial properties of the polyurethane foam coated with silver nanoparticles. The mechanism of antibacterial effect of silver nanoparticles has been reported in the literature, which suggests that the particles are bactericidal [8].

Polyurethane coating is an effective and protective coating applied on all kinds of concrete and steel surfaces, easily cleanable, without sintering, high abrasion resistance. Chemical and mechanical strength provide economical solution. It is a kind of uncoated and uncoated coating that is used in sports halls and industrial floors. Optionally, matte, bright and colored surfaces can be created.

Figure 7: Polyurethane floor coverings

Especially for dusty environments where dust will not accumulate and can be easily cleaned. This type of coating applied both inside and outside is resistant to sun rays and deformations such as cracking or drying.

Polyurethane is a polymer that has found many applications in the field of medicine. Silastic has been the standard material in the expanding technology for intravascular long-indwelling devices. This preference is due to its particular characteristics, which include its being biocompatible, soft, and nonthrombogenic. Although new materials for catheter manufacture have been developed, they have not proven to be safe for long duration.Polyurethane II is a flexible, soft, low-thrombogenic material that is suitable for long-stay. It also offers the advantage of low cost. This is particularly important in developing countries where patients may not be able to afford the cost of a tunneled silastic catheter or a subcutaneous port[9].

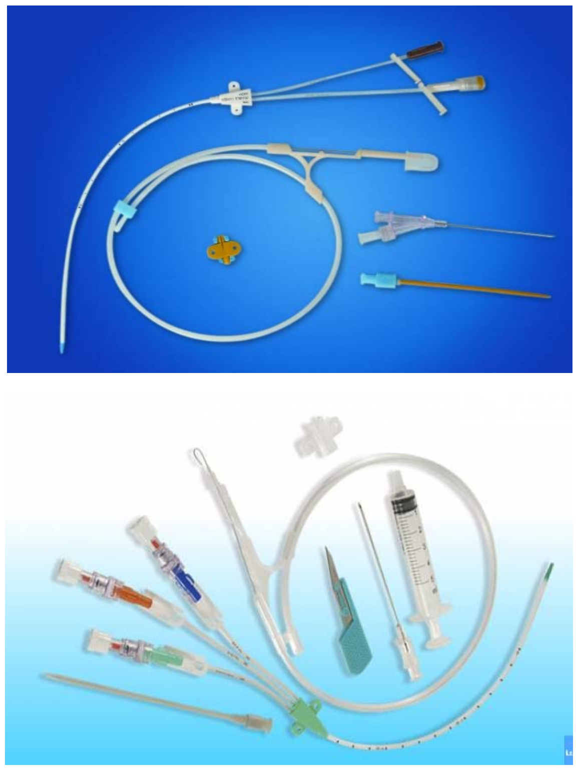


Figure 8: Polyurethane catheter samples

Hyperalimentation through indwelling central venous catheters is an accepted method of providing nutrition for low-birth-weight infants. The long-term use of intravenous catheters has been associated with serious complications (thrombosis, perforation, etc.). Recent attention, however, has focused on the occurrence of catheter-related sepsis due to coagulase-positive and coagulase-negative staphylococci. Although many factors are thought to contribute to the high incidence of sepsis in newborn infants with indwelling catheters, the effect of catheter composition on the adherence of microorganisms has received little attention. The recently introduced heparinbonded polyurethane (HBP) catheters are purported to decrease the incidence of thrombosis[10].

Stent implantation is of proven efficacy and safety for the treatment of coronary or saphenous vein graft occlusions. However, despite the reduction in restenosis rates, there is apparently no delay in the restenosis process, and myointimal proliferation and late lumen loss are not blunted after endovascular stent implantation. The excessive myointimal proliferative response seen with endovascular stenting has prompted clinicians to optimize stent deployment techniques, alter stent design and surface material, and develop new adjunctive strategies, including locally delivered radiation therapy and biocompatible polymers, to deliver drugs locally to the stented arteries.In the some work was designed to assess the arterial wall response to mechanical injury triggered by polyurethane-coated and uncoated stents in a rabbit carotid artery, and to determine whether this synthetic nonbiodegradable polymer is a biocompatible carrier for local stent-mediated drug delivery [11].

Although we use almost every area in our daily life, we do not know polyurethane; Automotive, sponge, shoes, transportation, refrigeration, insulation, furniture, textile, food, electronics, paint, industrial parts and health sector. Polyurethane foams are lightweight and more durable than flexible foam rubber foams and are easier to clean; Pillows, quilts and upholstery materials. Solid polyurethane foams are used for heat insulation in refrigerators and various areas. They are also used in aircraft construction because they are tightly bonded to metal surfaces.

References Références Referencias

1. D.K. Chattopadhyay, Dean C.Webster, Thermal stability and flame retardancy of polyurethanes, Progress in Polymer Science 34 (2009) 1068–1133.
2. Chattopadhyay DK, Raju KVSN. Structural engineering of polyurethane coatings for high performance applications. Prog Polym Sci 2007;32:352–418.
3. Cooper SL, Tobolsky AV., Properties of linear elastomeric Polyurethanes, J Appl Polym Sci 1966;10:1837–44.
4. P. Russo, M. Lavorgna, F. Piscitelli, D. Acierno, L. Di Maio, Thermoplastic polyurethane films reinforced with carbon nanotubes: The effect of processing on the structure and mechanical properties, European Polymer Journal xxx (2012) xxx–xxx
5. Jin-Chao Zhao, Fei-Peng Du, Xing-Ping Zhou, Wei Cui , Xiao-Mei Wang, Hong Zhu, Xiao-Lin Xie,Yiu-Wing Mai, Thermal conductive and electrical properties of polyurethane/hyperbranched poly(urea-urethane)-grafted multi-walled carbon nanotube composites, Composites: Part B 42 (2011) 2111–2116
6. Hao-Yang Mi, Zheng Li, Lih-Sheng Turng, Yugang Sun, Shaoqin Gong, Silver nanowire/thermoplastic polyurethane elastomer nanocomposites: Thermal, mechanical, and dielectric properties, Materials and Design 56 (2014) 398–404
7. Claudia Merlini, Valdir Soldi, Guilherme M.O. Barra, Influence of fiber surface treatment and length on physico-chemical properties of short random banana fiber-reinforced castor oil polyurethane composites, Polymer Testing 30 (2011) 833–840
8. JainP, Pradeep T.,Potential of silver nanoparticle-coated polyurethane foam as an antibacterial water filter, Biotechnol Bioeng. (2005) 5;90(1):59-63.
9. Patricia Volkow, MD,Carolina Va´zquez, RN,Odilia Te´llez, RN,Catalina Aguilar, RN,Laura Barrera, RN,Eneida Rodrı´guez, RN,Diana Vilar-Compte, MD, MsC,Juan Zinser, MD,Ernesto Caldero´n, MD,Jose´ Rogelio Pe´rez-Padilla, MD,and Alejandro Mohar, MD, ScD, Polyurethane II catheter as long-indwellingintravenous catheter in patients with cancer, Am J Infect Control 2003;31:392-6.
10. Pamela B. Russell, Jane Klıne, Mervın C. Yoder, And Rıchard A. Polın, Staphylococcal Adherence to Polyvinyl Chloride and Heparin-Bonded Polyurethane Catheters Is Species Dependent and Enhanced by Fibronectin, Journal of Clınıcal Mıcrobıology, June 1987, p. 1083-1087
11. Eldad Rechavia, MD, Frank Litvack, MD, Michael C. Fishbien, MD, Masato Nakamura, MD, and Neal Eigler, MD, Biocompatibility of Polyurethane-Coated Stents: Tissueand Vascular Aspects, Catheterization and Cardiovascular Diagnosis 45:202–207 (1998)

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