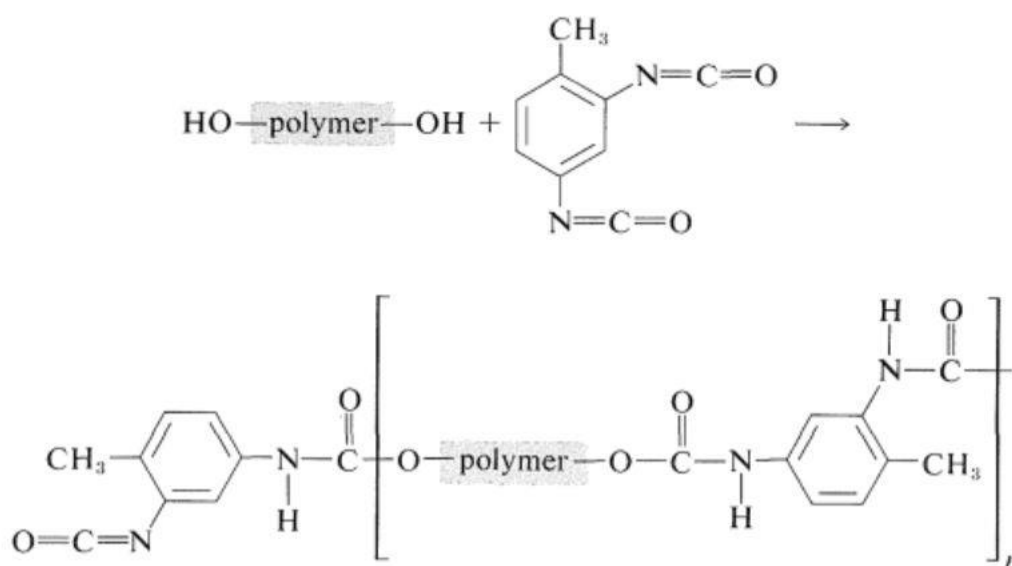


M.Sc. Sem I, CC-2, Physical Chemistry

Step-Growth Polymerization (continued...)

Polyurethane (continued...)

The very widely used polyurethane foams can be considered to be either block polymers or copolymers. The essential ingredients are a diisocyanate and a diol. The diisocyanate most used is 2,4-diisocyanato-1-methylbenzene, and the diol can be a polyether or a polyester with hydroxyl end groups. The isocyanate groups react with the hydroxyl end groups to form initially an addition polymer, which has polycarbamate (polyurethane) links, and isocyanate end groups:



A foam is formed by addition of the proper amount of water. The water reacts with the isocyanate end groups to form carbamic acids which decarboxylate to give amine groups:

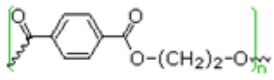
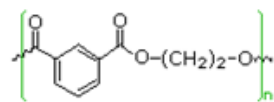
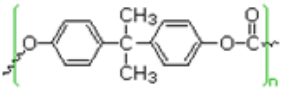
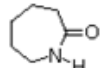
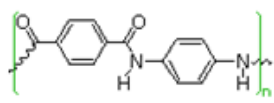
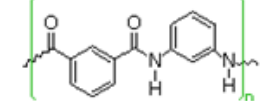


The carbon dioxide evolved is the foaming agent, and the amino groups formed at the same time extend the polymer chains by reacting with the residual isocyanate end groups to form urea linkages:



Polyurethanes are used in the manufacture of high-resilience foam seating, rigid foam insulation panels, microcellular foam seals and gaskets, durable elastomeric wheels and tires (such as roller coaster, escalator, shopping cart, elevator, and skateboard wheels), automotive suspension bushings, electrical potting compounds, high performance adhesives, surface coatings and surface sealants, synthetic fibers (e.g., Spandex), carpet underlay, hard-plastic parts (e.g., for electronic instruments), condoms, and hoses.

Common Step Growth Polymers

Formula	Type	Components	T _g °C	T _m °C
$\sim[\text{CO}(\text{CH}_2)_4\text{CO}-\text{OCH}_2\text{CH}_2\text{O}]_n\sim$	polyester	HO ₂ C-(CH ₂) ₄ -CO ₂ H HO-CH ₂ CH ₂ -OH	< 0	50
	polyester Dacron, Mylar	para HO ₂ C-C ₆ H ₄ -CO ₂ H HO-CH ₂ CH ₂ -OH	70	265
	polyester	meta HO ₂ C-C ₆ H ₄ -CO ₂ H HO-CH ₂ CH ₂ -OH	50	240
	polycarbonate Lexan	(HO-C ₆ H ₄) ₂ C(CH ₃) ₂ (Bisphenol A) X ₂ C=O (X = OCH₃ or Cl)	150	267
$\sim[\text{CO}(\text{CH}_2)_4\text{CO}-\text{NH}(\text{CH}_2)_6\text{NH}]_n\sim$	polyamide Nylon 66	HO ₂ C-(CH ₂) ₄ -CO ₂ H H ₂ N-(CH ₂) ₆ -NH ₂	45	265
$\sim[\text{CO}(\text{CH}_2)_5\text{NH}]_n\sim$	polyamide Nylon 6 Perlon		53	223
	polyamide Kevlar	para HO ₂ C-C ₆ H ₄ -CO ₂ H para H ₂ N-C ₆ H ₄ -NH ₂	---	500
	polyamide Nomex	meta HO ₂ C-C ₆ H ₄ -CO ₂ H meta H ₂ N-C ₆ H ₄ -NH ₂	273	390