

高等学校教材

高分子材料工程 专业英语

第二版

大学英语专业阅读教材编写委员会组织编写

曹同玉 冯连芳 张菊华 主编



化学工业出版社

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·北京·

本书是《高分子材料工程专业英语》的第二版，是“大学英语专业阅读教材编写委员会”组织编写的高等学校化工专业英语系列教材之一。全书共分 32 课，包括高分子化学、高分子物理、聚合反应工程、聚合物性能、成型加工及应用，以及高分子材料的实验、研制与生产等多方面的内容。每课均由课文、重点词汇（单词、音标及解释）、词组、课文注释、练习、阅读材料等部分组成。

本书主要作为全国各高等院校高分子专业英语教材，也可作为从事高分子合成、成型加工、研制及应用工作的科技人员、教师及研究生提高专业英语水平的参考用书。

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第二版前言

《高分子材料工程专业英语》第一版是由“大学英语专业阅读教材编写委员会”于1998年组织编写的高等学校化工专业英语系列教材之一。该教材编写委员会是由华东理工大学、北京化工大学、华南理工大学、四川大学、大连理工大学、天津大学、浙江大学、南京化工大学等十四所化工专业实力较强的高等院校组成的，由华东理工大学资深教授朱炳辰先生任主任委员。本书第一版是在大学英语专业阅读教材编写委员会的领导下，在化学工业出版社的支持下，由天津大学（曹同玉）、浙江大学（冯连芳）、四川大学（张菊华等）联合编写的。

自从1999年第一版出版以来，本书受到了广大读者的关注，已被全国许多高等院校和部分中等专业学校的高分子材料专业、高分子化工专业、材料科学与工程等专业用做专业英语教材；同时也有不少在分子科学与技术领域里工作的工程技术人员、研究人员、准备晋升职称的人员、准备出国留学人员、在校研究生等把此书作为提高高分子专业英语水平的基本阅读材料，受到了广大读者的青睐，给予了较高的评价，同时也提出了许多宝贵意见和建议，使编者受益匪浅，在此向广大读者深表谢意。

本书第一版出版至今已有十多年之久，已重印10余次，鉴于采用此教材的各校师生在专业英语教学过程中发现了书中存在的一些缺陷，需要修改；同时，作为一本高等学校教材也应当不断提炼，不断更新，不断提高，以期获得更好的教学效果；再者，近年来高分子科学又有了新的发展，在教材中应当有所反映，有所充实，因此，化学工业出版社决定再版此书。受化学工业出版社的委托，在向多所院校相关师生进行了调查研究的基础上，由曹同玉执笔，对本书第一版进行了全面的重新审订、勘误、修改、删节、增补和编排，认真地进行了文字推敲；同时还引入了在分子领域里新近出现的活性自由基聚合等新章节，并充实了高分子物理方面的相关内容，可望《高分子材料工程专业英语》第二版能更好地满足广大读者对高分子专业英语教材越来越高的要求。

在本书第二版的修订和编写过程中，得到了袁才登、瞿雄伟、肖继君、郭睿威、董岸杰、赵万里等各位同仁的大力帮助，并提出了许多宝贵意见和建议，编者表示诚挚的谢意。

限于编者水平，再版后的书中一定还会有不尽如人意之处，恳请各位老师、各位同学及其他读者批评指正。

编者
2011.1

前 言

组织编审出版系列的专业英语教材，是许多院校多年来共同的愿望。在高等教育面向 21 世纪的改革中，学生基本素质和实际工作能力的培养受到了空前重视。对非英语专业的学生而言，英语水平和能力的培养不仅是文化素质的重要部分，在很大程度上也是能力的补充和延伸。在此背景下，教育部（原国家教委）几次组织会议研究加强外语教学问题，制订相关规范，使外语教学更加受到重视。教材是教学的基本要素之一，与基础英语相比，专业英语教学的教材问题此时显得尤为突出。

国家主管部门的重视和广大院校的呼吁引起了化学工业出版社的关注，他们及时地与原化工部教育主管部门和全国化工类专业教学指导委员会请示协商后，组织全国十余所院校成立了大学英语专业阅读教材编委会。在经过必要的调研后，根据学校需求，编委会优先从各校教学（交流）讲义中确定选题，同时组织力量开展编审工作。本套教材涉及的专业主要包括化学工程与工艺、石油化工、机械工程、信息工程、生产过程自动化、应用化学及精细化工、生化工程、环境工程、制药工程、材料科学与工程、化工商贸等。

于 20 世纪 70 年代末期，全国各化工院校高分子材料与高分子化工专业都相继开设了“高分子专业英语”课。这门课为完成由基础英语向专业英语的过渡，提高学生阅读高分子专业文献资料的能力发挥了重要作用。但是，对于“高分子专业英语”这门课，不同学校，即使同一学校的不同教师，甚至同一教师在不同年份，所用教材、教学内容、教学要求和教学方法都不尽相同，给人们的印象是这门课的随意性很大，没有一定可遵循的规范，教学质量也因地、因人、因时而异，这很不利于学生专业英语能力的培养。如果能编写一本“高分子专业英语”全国统编教材，各学校都按照这本教材的内容和要求进行规范的教学，对于克服目前“高分子专业英语”课教学的混乱状态，无疑会起到至关重要的作用。

这本《高分子材料工程专业英语》即是根据“全国部分高校化工类及相关专业大学英语专业阅读教材编审委员会”的要求和安排编写的。全书共分 32 课，包括高分子化学、高分子物理、聚合反应工程、聚合物性能、成型加工及应用，以及高分子材料的实验、研制与生产等多方面的内容。每课均由课文、重点词汇（单词、音标及解释）、词组、课文注释、练习、阅读材料等部分构成。每课的课文和阅读材料均为彼此独立的短文，取材于不同国家、不同作者的 48 种英文高分子专业书籍、会议论文集、期刊、专利等英文原文资料，集不同语言风格为一体，具有词汇量大及科技英语语法覆盖面广等特点。本书主要作为全国各高等院校高分子专业英语教材，也可以作为从事高分子合成、成型加工、研制及应用工作的科技人员、教师及研究生提高专业英语水平的参考书。

本书分工情况为：Unit1~Unit10 由曹同玉、袁才登编写，Unit11~Unit20 由冯连芳编写，Unit21、Unit27 及 Unit28 由李瑞海编写，Unit22、Unit23 及 Unit26 由雷勇编写，Unit24、Unit31 及 Unit32 由孙树东编写，Unit25、Unit29 及 Unit30 由胡泽容编写。全书由曹同玉、冯连芳主编，由张菊华、欧阳庆主审。在编写过程中承蒙方道斌、姚兆玲、刘德华、陈锦言、赵勇等同志进行了审阅与校核，提出了许多宝贵意见，并给予了多方面的帮助，在此深表谢意。限于作者水平，书中一定会有不少错误，望读者批评指正。

编者
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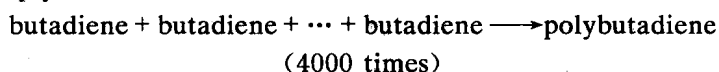
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PART A Polymer Chemistry and Physics

UNIT 1 What Are Polymers?

What are polymers? For one thing, they are complex and giant molecules and are different from low molecular weight compounds like, say, common salt. To contrast the difference, the molecular weight of common salt is only 58.5, while that of a polymer can be as high as several hundred thousands, even more than thousand thousands. These big molecules or 'macro-molecules' are made up of much smaller molecules. The small molecules, which combine to form a big molecule, can be of one or more chemical compounds. To illustrate, imagine that a set of rings has the same size and is made of the same material. When these rings are interlinked, the chain formed can be considered as representing a polymer from molecules of the same compound. Alternatively, individual rings could be of different sizes and materials, and interlinked to represent a polymer from molecules of different compounds.

This interlinking of many units has given the polymer its name, *poly* meaning 'many' and *mer* meaning 'part' (in Greek). As an example, a gaseous compound called butadiene, with a molecular weight of 54, combines nearly 4000 times and gives a polymer known as polybutadiene (a synthetic rubber) with about 200000 molecular weight. The low molecular weight compounds from which the polymers form are known as monomers. The picture is simply as follows:



One can thus see how a substance (monomer) with as small a molecular weight as 54 grows to become a giant molecule (polymer) of $(54 \times 4000 \approx) 200000$ molecular weight. It is essentially the 'giantness' of the size of the polymer molecule that makes its behavior different from that of a commonly known chemical compound such as benzene. ^① Solid benzene, for instance, melts to become liquid benzene at 5.5°C and, on further heating, boils into gaseous benzene. As against this well-defined behavior of a simple chemical compound, a polymer like polyethylene does not melt sharply at one particular temperature into clean liquid. Instead, it becomes increasingly softer and, ultimately, turns into a very viscous, tacky molten mass. Further heating of this hot, viscous, molten polymer does convert it into various gases but it is no longer polyethylene (Fig. 1.1).

Another striking difference with respect to the behavior of a polymer and that of a low molecular weight compound concerns the dissolution process. Let us take, for example, sodium chloride and add it slowly to a fixed quantity of water. The salt, which represents a low molecular weight compound, dissolves in water up to a point (called saturation point) but, thereafter, any

further quantity added does not go into solution but settles at the bottom and just remains there as solid. The viscosity of the saturated salt solution is not very much different from that of water. But if we take a polymer instead, say, polyvinyl alcohol, and add it to a fixed quantity of water, the polymer does not go into solution immediately. The globules of polyvinyl alcohol firstly absorb water, swell and get distorted in shape and after a long time go into solution. ② Also, we can add a very large quantity of the polymer to the same quantity of water without the saturation point ever being reached. As more and more quantity of polymer is added to water, the time taken for the dissolution of the polymer obviously increases and the mix ultimately assumes a soft, dough-like consistency. Another peculiarity is that, in water, polyvinyl alcohol never retains its original powdery nature as the excess sodium chloride does in a saturated salt solution. ③ In conclusion, we can say that (1) the long time taken by polyvinyl alcohol for dissolution, (2) the absence of a saturation point, and (3) the increase in the viscosity are all characteristics of a typical polymer being dissolved in a solvent and these characteristics are attributed mainly to the large molecular size of the polymer. The behavior of a low molecular weight compound and that of a polymer on dissolution are illustrated in Fig. 1.2.

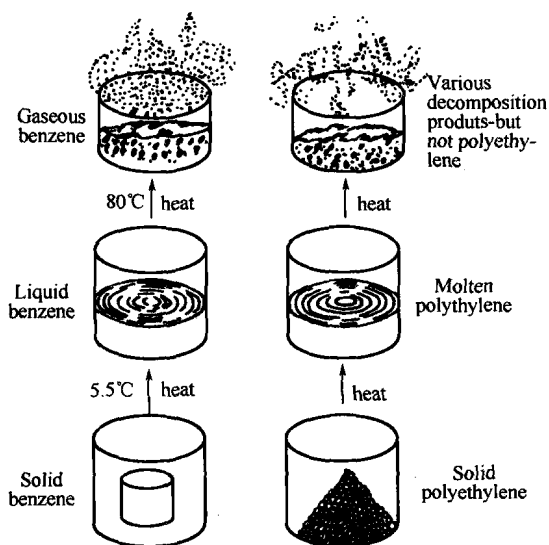


Fig. 1.1 Difference in behavior on heating of a low molecular weight compound (benzene) and a polymer (polyethylene)

—Gowariker V R, Viswanathan N V, Sreedhar J. Polymer Science. New York: John Wiley & Sons, 1986. 6

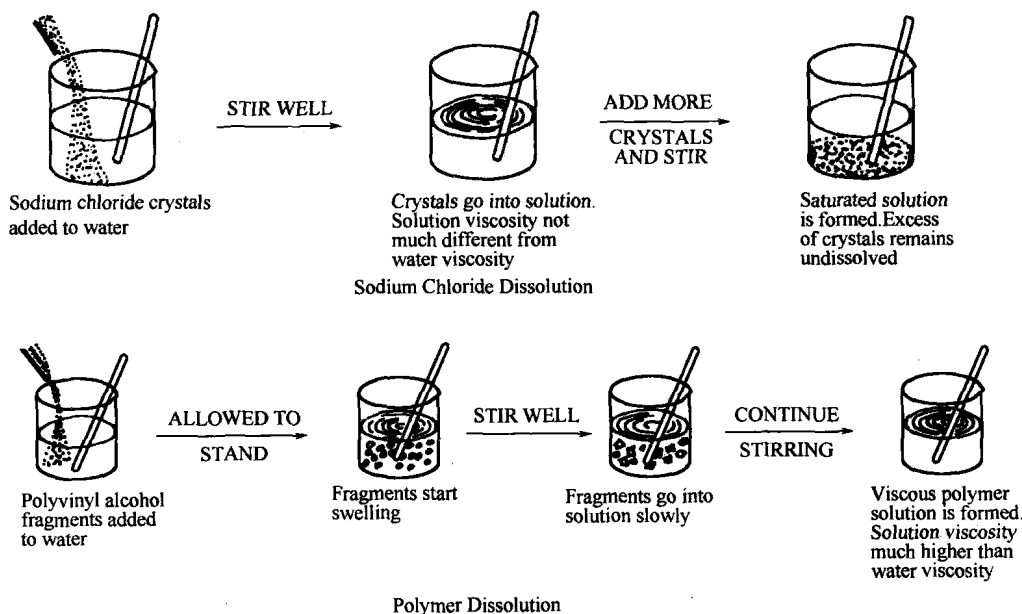


Fig. 1.2 Difference in solubility behaviour of a low molecular weight compound (sodium chloride) and a polymer (polyvinyl alcohol)

Words and Expressions

polymer	[ˈpɒlɪmə]	n.	聚合物 [体], 高聚物
common salt			食盐
macromolecule	[ˌmækroˈmɒlɪkjʊ:l]	n.	大分子, 高分子
imagine	[ɪˈmædʒɪn]	v.	想象, 推测
interlink	[ɪntəˈlɪŋk]	v.	把...相互连接起来
		n.	连接
butadiene	[ˌbju:təˈdaɪ:n]	n.	丁二烯
monomer	[ˈmɒnəmə]	n.	单体
synthetic	[sɪnˈθetɪk]	a.	合成的
behavior	[biˈheɪvjə]	n.	性能, 行为
polyethylene	[ˌpɒliˈeθɪli:n]	n.	聚乙烯
viscous	[ˈvɪskəs]	a.	黏稠的
tacky	[ˈtæki]	a.	(表面)发黏的
		n.	粘连 [搭] 性
dissolution	[dɪsəˈlu:ʃən]	n.	溶解
dissolve	[dɪˈsɒlv]	v.	使...溶解
saturation	[sætʃəˈreɪʃən]	n.	饱和
settle	[ˈsetl]	v.	沉淀 [降], 澄清
viscosity	[vɪsˈkɒsɪti]	n.	黏度 [性]
polyvinyl alcohol			聚乙烯醇
globule	[ˈɡlɒbjʊ:l]	n.	小球, 液滴, 颗粒
swell	[swel]	v. ; n.	溶胀
distort	[dɪsˈtɔ:t]		使...变形, 扭曲
dough	[daʊ]	n.	(生) 面团, 揉好的面
consistency	[kənˈsɪstənsɪ]	n.	稠度, 黏稠性
powdery	[ˈpaʊdəri]	a.	粉状的
solvent	[ˈsɒlvənt]	n.	溶剂
peculiarity	[pɪkju:lɪˈærɪti]	n.	特性
crystal	[ˈkrɪstl]	n.	晶体, 结晶
fragment	[ˈfræɡmənt]	n.	碎屑, 碎片

Phrases

for one thing 首先	with respect to 关于, 就...而论
as an example 例如, 举例来说	a quantity of... 大量, 一些
as against 和...比起来, 和...相对照	in conclusion 总之, 最后
convert...into... 把...转变 [化] 成...	be attributed to... 归因于, 认为是...的结果

Notes

- ① “It is essentially the ‘giantness’ of the size of the polymer molecule that makes its behavior different from that of a commonly known chemical compound such as benzene.” 此处 It is... that... 为强调语气结构。the ‘giantness’ of the size of the polymer molecule 为被强调的句子的主语, 可译为“巨大的聚合物分子尺寸”。句子的谓语是“makes”。“its behavior”是“makes”的宾语, 可译为“聚合物的性能”。“different from...”为宾语补足语, 其后的“that”代替前面已出现过的“behavior”, 以避免重复。该句译文为: “实质上, 正是由于聚合物的巨大的分子尺寸才使其性能不同于像苯这样的一般化合物 (的性能)。”
- ② “The globules of polyvinyl alcohol firstly absorb water, swell and get distorted in shape and after a long time go into solution.” 是一个简单句, “the globules”为主语, 作“球粒”或“颗粒”解。本句有四个并列的谓语, 即 absorb、swell、get distorted 及 go into。“get distorted in shape”为“get + 过去分词”表示的被动语态。全句的译文是: “聚乙烯醇颗粒首先吸水溶胀, 发生形变, 经过很长的时间以后, (聚

乙醇分子) 进入到溶液中。”

- ③ “Another peculiarity is that, in water, polyvinyl alcohol never retains its original powdery nature as the excess sodium chloride does in a saturated salt solution.” 从属连接词 *that* 所引导的从句是表语从句, 从句的宾语 “its original powdery nature” 可译成 “其初始的粉末状态”。最后是 *as* 引导的方式方法状语从句, 从句中的 “does” 用于替代前面出现的动词 “retains”。全句译文为: “另一个特点是, 在水中聚乙烯醇不会像过量的氯化钠在饱和盐溶液中那样能保持其初始的粉末状态。”

Exercises

1. Translate the following into Chinese

Not all polymers are built up from bonding together a single kind of repeating unit. At the other extreme, protein molecules are polyamides in which n amino acid repeat units are bonded together. Although we might still call n the degree of polymerization in this case, it is less useful, since an amino acid unit might be any one of some 20-odd molecules that are found in proteins. In this case the molecular weight itself, rather than the degree of polymerization, is generally used to describe the molecule. When the actual content of individual amino acids is known, it is their sequence that is of special interest to biochemists and molecular biologists.

2. Give a definition for each following word

- (1) molecule
- (2) monomer
- (3) polymer

3. Put the following words into Chinese

structure data equation pressure liquid laboratory solid
molecule temperature measurement compound electrical

4. Put the following words into English

科学 技术 化学 物理 气体 原子 性质 试验 增加 减少 混合物

[Reading Materials]

Structure of Polymer Chains

In many cases polymer chains are linear. In evaluating both the degree of polymerization and the extended chain length, we assume that the chain has only two ends. While linear polymers are important, they are not the only type of molecules possible. Branched and cross-linked molecules are also important. When we speak of a branched polymer, we refer to the presence of additional polymeric chains issuing from the backbone of a linear molecule. Substituent groups such as methyl or phenyl groups on the repeat units are not considered branches. Branching is generally introduced into a molecule by intentionally adding some monomer with the capability of serving as a branch. Let us consider the formation of a polyester. The presence of difunctional acids and difunctional alcohols allows the polymer chain to grow. These difunctional molecules are incorporated into the chain with ester linkages at both ends of each. Trifunctional acids or alcohols, on the other hand, produce a linear molecule by reacting two of their functional groups. If the third reacts and the resulting chain continues to grow, a branch has been introduced into the original chain. Adventitious branching sometimes occurs as a result of an atom being abstracted from the original linear molecule, with chain growth occurring from the resulting active site. Molecules with this kind of accidental branching are generally still called linear, although the presence of significant branching has profound effects on some properties of the polymer, most notably the tendency to undergo crystallization.

The amount of branching introduced into a polymer is an additional variable that must

be specified for the molecule to be fully characterized. When only a slight degree of branching is present, the concentration of junction points is sufficiently low that these may be simply related to the number of chain ends. For example, two separate linear molecules have a total of four ends. If the end of one of these linear molecules attaches itself to the middle of the other to form a "T", the resulting molecule has three ends. It is easy to generalize this result. If a molecule has ν branches, it has $\nu + 2$ chain ends if the branching is relatively low. Branched molecules are sometimes described as either combs or stars. In the former, branch chains emanate from along the length of a common backbone; in the latter, all branches radiate from a central junction.

If the concentration of junction points is high enough, even branches will contain branches. Eventually a point is reached at which the amount of branching is so extensive that the polymer molecule becomes a giant three dimensional network. When this condition is achieved, the molecule is said to be cross-linked. In this case, an entire macroscopic object may be considered to consist of essentially one molecule. The forces which give cohesiveness to such a body are covalent bonds, not intermolecular forces. Accordingly, the mechanical behavior of cross-linked bodies is much different from those without cross-linking.

Just as it is not necessary for polymer chains to be linear, it is also not necessary for all repeat units to be the same. We have already mentioned molecules like proteins where a wide variety of different repeat units are present. Among synthetic polymers, those in which a single kind of repeat unit are involved are called homopolymers, and those containing more than one kind of repeat unit are copolymers. Note that these definitions are based on the repeat unit, not the monomer. An ordinary polyester is not a copolymer, even though two different monomers, acids and alcohols, are its monomers. By contrast, copolymers result when different monomers bond together in the same way to produce a chain in which each kind of monomer retains its respective substituents in the polymer molecule. The unmodified term *copolymer* is generally used to designate the case where two different repeat units are involved. Where three kinds of repeat units are present, the system is called a terpolymer; where there are more than three, the system is called a multi-component copolymer.

The moment we admit the possibility of having more than one kind of repeat unit, we require additional variables to describe the polymer. First, we must know how many kinds of repeat units are present and what they are. This is analogous to knowing what components are present in a solution, although the similarity ends there, since the repeat units in a polymer are bonded together and not merely mixed. To describe the copolymer quantitatively, the relative amounts of the different kinds of repeat units must be specified. Thus the empirical formula of a copolymer may be written $A_x B_y$, where A and B signify the individual repeat units and x and y indicate the relative number of each. From a knowledge of the molecular weight of the polymer, the molecular weights of A and B, and the values of x and y , it is possible to calculate the number of each kind of monomer unit in the copolymer. The sum of these values gives the degree of polymerization of the copolymer. Note that we generally do not call n_A and n_B the degrees of polymerization of the individual units. The inadvisability of the latter will become evident presently.

—Hiemenz P C. *Polymer Chemistry*. New York: Marcel Dekker, 1984. 9

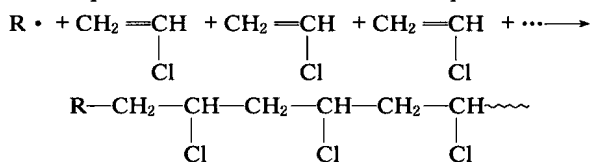
Words and Expressions

linear polymer			线形聚合物
branched polymer			支链聚合物
homopolymer	[hɒmə'pɒlɪmə]	<i>n.</i>	均聚物
backbone	['bækbəʊn]	<i>n.</i>	主链
polyester	[pɒli'estə]	<i>n.</i>	聚酯
difunctional	[di'fʌŋkʃən]	<i>a.</i>	二 [双] 官能度的
crystallization	[kristəlaɪ'zeɪʃən]	<i>n.</i>	结晶 (作用)
emanate	['eməneɪt]	<i>v.</i>	源于, 发源, 发出, 放射 (出)
cohesiveness	[kəu'hi:sɪvnis]	<i>n.</i>	内聚性 [力], 黏结性
terpolymer	[tə:'pɒlɪmə]	<i>n.</i>	三元共聚物
inadvisability	[ɪnədvaɪzə'bɪlɪtɪ]	<i>n.</i>	不合理 (性), 不适当

UNIT 2 Chain Polymerization

Many olefinic and vinyl unsaturated compounds are able to form chain-like macromolecules through elimination of the double bond, a phenomenon first recognized by Staudinger. Diolefins polymerize in the same manner, however, only one of the two double bonds is eliminated. Such reactions occur through the initial addition of a monomer molecule to an initiator radical or an initiator ion, by which the active state is transferred from the initiator to the added monomer. ^① In the same way, by means of a chain reaction, one monomer molecule after the other is added (2000~20000 monomers per second) until the active state is terminated through a different type of reaction. The polymerization is a chain reaction in two ways; because of the reaction kinetics and because as a reaction product one obtains a chain molecule. The length of the chain molecule is proportional to the kinetic chain length.

One can summarize the process as follows ($R \cdot$ is equal to the initiator radical):



One thus obtains polyvinylchloride from vinylchloride, or polystyrene from styrene, or polyethylene from ethylene, etc.

The length of the chain molecules, measured by means of the degree of polymerization, can be varied over a large range through selection of suitable reaction conditions. Usually, with commercially prepared and utilized polymers, the degree of polymerization lies in the range of 1000 to 5000, but in many cases it can be below 500 and over 10000. This should not be interpreted to mean that all molecules of a certain polymeric material consist of 500, or 1000, or 5000 monomer units. In almost all cases, the polymeric material consists of a mixture of polymer molecules of different degrees of polymerization.

Polymerization, a chain reaction, occurs according to the same mechanism as the well-known chlorine-hydrogen reaction and the decomposition of phosgene.

The initiation reaction, which is the activation process of the double bond, can be brought about by heating, irradiation, ultrasonics, or initiators. The initiation of the chain reaction can be observed most clearly with radical or ionic initiators. ^② These are energy-rich compounds which can add suitable unsaturated compounds (monomers) and maintain the activated radical or ionic state so that further monomer molecules can be added in the same manner. ^③ For the individual steps of the growth reaction one needs only a relatively small activation energy and therefore through a single activation step (the actual initiation reaction) a large number of olefin molecules are converted, as is implied by the term "chain reaction". ^④ Because very small amounts of the initiator bring about the formation of a large amount of polymeric material (1 : 1000 to 1 : 10000), it is possible to regard polymerization from a superficial point of view as a catalytic reaction. For this reason, the

initiators used in polymerization reactions are often designated as polymerization catalysts, even though, in the strictest sense, they are not true catalysts because the polymerization initiator enters into the reaction as a real partner and can be found chemically bound in the reaction product, i. e., the polymer. In addition to the ionic and radical initiators there are now metal complex initiators (which can be obtained, for example, by the reaction of titanium tetrachloride or titanium trichloride with aluminum alkyls), which play an important role in polymerization reactions (Ziegler catalysts). The mechanism of their catalytic action is not yet completely clear.

—Vollmert B. Polymer Chemistry. Berlin: Springer-Verlag, 1973. 40

Words and Expression

olefinic	[əule'finik]	a.	烯烃的
vinyl	['vainil]	n.; a.	乙烯基(的)
unsaturated	[ʌn'sætʃəreitid]	a.	不饱和的
eliminate	[i'limineit]	v.	消除, 打开, 除去
double bond		n.	双键
diolefin	[dai'əulefin]	n.	二烯烃
transfer	['træsfə:]	v.	(链)转移, (热)传递
initiator	[i'nijieite]	n.	引发剂
radical	['rædikəl]	n.	自由基
chain reaction			连锁反应
terminate	['tə:mineit]	v.	(链)终止
kinetic chain length			动力学链长
polyvinylchloride	[pɒli'vainil'klɔraɪd]	n.	聚氯乙烯
polystyrene	[pɒli'staɪərɪn]	n.	聚苯乙烯
degree of polymerization			聚合度
polymeric	[pɒli'merik]	a.	聚合(物)的
mechanism	['mekənizəm]	n.	机理[制]
chlorine	['klɔ:ri:n]	n.	氯(气)
hydrogen	['haɪdrɪdʒən]	n.	氢(气)
decomposition	[di:kəmpe'ziʃən]	n.	分解
phosgene	['fɔzdʒi:n]	n.	光气, 碳酰氯
initiation	[iniʃi'eɪʃən]	n.	(链)引发
activation	[ækti'veɪʃən]	n.	活化(作用)
irradiation	[ɪreɪdi'eɪʃən]	n.	照射, 辐照
ultrasonic	[ʌltrə'sɒnik]	n.	超声波
catalyst	['kætəlist]	n.	催化剂, 触媒
ionic	['aɪ'ɒnik]	a.	离子的
complex	['kɒmpleks]	n.	络合物
titanium tetrachloride			四氯化钛
titanium trichloride			三氯化钛
aluminum alkyl			烷基铝

Phrases

by means of... 借助于...	bring about 引起, 产生, 导致
one...after the other 一个接一个...	energy-rich 高能(级)的
be proportional to... 和...成正比	from a superficial point of view 从表面上看
over a large range 在很大的范围内	in the strictest sense 严格地讲[说]
lie in... 处于, 落在, 在于	play an important role in... 在...方面起重要作用

Notes

- ① “Such reactions occur through the initial addition of a monomer molecule to an initiator radical or an initiator ion, by which the active state is transferred from the initiator to the added monomer.” 主语 “such reaction” 是指上面所提到的打开单体双键而形成聚合物的反应。谓语 “occur” 后面为由 “through” 引导的介词短语作方式状语，可译为 “这些反应是通过…而进行的”。最后为非限定性的定语从句，不是说明某个名词，而是说明前面整个句子。“by which” 在从句中作方式状语。“active state” 可译作 “活性中心”。全句译文：“这样的反应是通过单体分子首先加成到引发剂自由基或引发剂离子上而进行的，靠这些反应活性中心由引发剂转移到被加成的单体上。”
- ② “The initiation of the chain reaction can be observed most clearly with radical or ionic initiators.” 该句是一个简单句，句末介词短语 “with radical or ionic initiators” 是主语 “the initiation” 的定语，为了使句子匀称，避免头重脚轻，后置定语没有紧接它要说明的主语，而是被其他成分如谓语等分隔开，这在英语语法中称作分割现象，被分割的定语可以是介词短语，也可以是定语从句。该句是一个起后置定语作用的介词短语被分割的例句，可译作：“用自由基型引发剂或离子型引发剂引发连锁反应可以很清楚地进行观察。”
- ③ “These are energy-rich compounds which can add suitable unsaturated compounds (monomers) and maintain the activated radical, or ionic, state so that further monomer molecules can be added in the same manner.” 主句的表语 “energy-rich compounds” 意指 “高能态化合物”，紧跟其后的句子为以 “which” 引导的定语从句。最后为由 “so that” 引导的结果从句。全句译文为：“这些（化合物）是高能态化合物，它们可以加成不饱和化合物（单体），并且（在完成一步加成以后仍然）可以保持自由基活性中心或离子活性中心，致使单体分子可以用同样的方式进一步加成。”
- ④ “For the individual steps of the growth reaction one needs only a relatively small activation energy and therefore through a single activation step (the actual initiation reaction) a large number of olefin molecules are converted, as is implied by the term ‘chain reaction.’” 句中主语 “one” 用以代表前面的复数名词 “steps”，“one” 是单数，意指在 “steps” 中的一步。句子的最后为 as 引导的定语从句，用以说明前面整个句子，“as” 在从句中作主语。全句译文为：“对于链增长反应的诸多步骤来说，每一步仅需要相当少的活化能，因此，通过一步简单的活化反应（即引发反应）即可将许多烯类单体分子转化（成聚合物），这正如连锁反应这个术语的内涵那样。”

Exercises

1. Please fill in the correct answers into the blanks in the following passage

Another striking difference with respect to the behavior of a polymer and _____ of a low molecular weight compound concerns the dissolution process. Let us take, for example, sodium chloride and add it slowly to a fixed _____ of water. The salt, which represents a _____ molecular weight compound, dissolves in water up to a point (called _____ point) but, thereafter, any further quantity added does not go into solution but settles at the _____ and just remains there as solid. The viscosity of the saturated salt solution is not very _____ different from that of water. But if we take a polymer instead, say, polyvinyl alcohol, and add it to a fixed quantity of water, the polymer does not go into solution immediately. The globules of polyvinyl alcohol first _____ water, swell and get distorted in shape and after a long time go into solution.

2. Translate the following into English

乙烯分子带有一个双键，为一种烯烃，它可以通过连锁聚合大量地制造聚乙烯，目前，聚乙烯已经广泛地应用于许多技术领域和人们的日常生活中，成为一种不可缺少的材料。

3. Put the following words into Chinese

macromolecule tacky settle behavior molten polymer distort viscous butadiene synthetic globule powdery fragment

4. Put the following words into English

氯化钠 黏度 吸收 溶胀 单体 苯 分子量 化合物 溶液 形状 低分子化合物 高分子化合物

[Reading Materials]

Overall Kinetics of Chain Polymerization

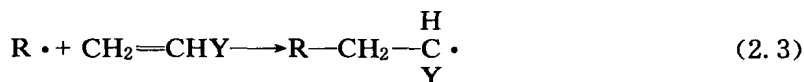
Radical chain polymerization is a chain reaction consisting of a sequence of three steps—*initiation*, *propagation* and *termination*. The initiation step is considered to involve two reactions. The first is the production of free radicals by any one of a number of reactions. The usual case is the homolytic dissociation of an initiator or catalyst species I to yield a pair of radicals R •



where k_d is the rate constant for the catalyst dissociation. The second part of the initiation involves the addition of this radical to the first monomer molecule to produce the chain initiating species $M_1 \cdot$



where M represents a monomer molecule and k_i is the rate constant for the initiation step [Eq. (2.2)]. For the polymerization of $\text{CH}_2=\text{CHY}$, Eq. (2.2) takes the form



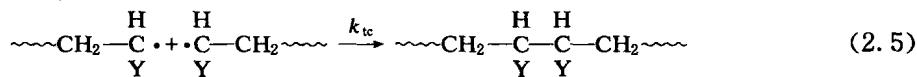
The radical R • is often referred to as an initiator radical or a primary radical.

Propagation consists of the growth of $M_1 \cdot$ by the successive additions of large numbers (hundreds, and perhaps, thousands) of monomer molecules. Each addition creates a new radical which has the same identity as the one previously, except that it is larger by one monomer unit. The successive additions may be represented in general terms by

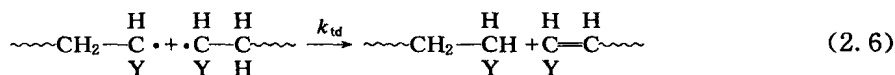


where k_p is the rate constant for propagation. Propagation with growth of the chain to high polymer proportions takes place very rapidly. The value of k_p for the most monomers is in the range of $10^2 \sim 10^4$ L/(mol • s). This is a large rate constant—much larger than those usually encountered in chemical reactions.

At some point, the propagating polymer chain stops growing and terminates. Termination with the annihilation of the radical centers occurs by bimolecular reaction between radicals. Two radicals react with each other by *combination* (*coupling*)



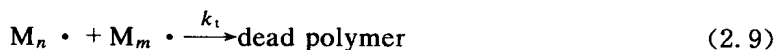
or, more rarely, by disproportionation in which a hydrogen radical that is beta to one radical center is transferred to another radical center. This results in the formation of two polymer molecules—one saturated and one unsaturated.



Termination can also occur by a combination of coupling and disproportionation. The two different modes of termination can be represented in general terms by



where k_{tc} and k_{td} are the rate constants for termination by coupling and disproportionation, respectively. One can also express the termination step by



where the particular mode of termination is not specified and

$$k_t = k_{tc} + k_{td} \quad (2.10)$$

The term *dead polymer* signifies the cessation of growth for the propagation radical. The propagation reaction would proceed indefinitely until all the monomer in a reaction system were exhausted if it were not for the strong tendency toward termination. Typical termination rate constants are in the range of $10^6 \sim 10^8$ L/(mol · s) or orders of magnitude greater than the propagation rate constants. The much greater value of k_t (whether k_{tc} or k_{td}) compared to k_p does not prevent propagation because the radical species are present in very low concentrations and because the polymerization rate is dependent on only the one-half power of k_t .

Equations (2.1) through (2.5) constitute the detailed mechanism of a free radical initiated chain polymerization. The chain nature of the process resides in the propagation step (Eq. (2.4)) in which large numbers of monomer molecules are converted to polymer for each initial radical species produced in the first step (Eq. (2.1)). In order to obtain a kinetic expression for the overall rate of polymerization, it is necessary to assume that k_p and k_t are independent of the size of the radical. This is exactly the same type of assumption which was employed in deriving the kinetics of step polymerization. There is ample experimental evidence which indicates that although radical reactivity depends on molecular size, the effect of size vanishes after the pentamer or hexamer.

Monomer disappears by the initiation reaction (Eq. (2.2) and (2.3)) as well as by the propagation reactions (Eq. (2.4)). The *rate of monomer disappearance*, which is synonymous with the *rate of polymerization*, is given by

$$-\frac{d[M]}{dt} = R_i + R_p \quad (2.11)$$

where R_i and R_p are the rates of initiation and propagation, respectively. However, the number of monomer molecules reacting in the initiation step is far less than the number in the propagation step for a process producing high polymer. To a very close approximation, the former can be neglected and the polymerization rate is given simply by the rate of propagation

$$-\frac{d[M]}{dt} = R_p \quad (2.12)$$

The rate of propagation, and therefore, the rate of polymerization, is the sum of many individual propagation steps. Since the rate constants for all the propagation steps are the same, one can express the polymerization rate by

$$R_p = k_p [M \cdot] [M] \quad (2.13)$$

where $[M]$ is the monomer concentration and $[M \cdot]$ is the total concentration of all chain radicals, i. e., all radicals of size $M_1 \cdot$ and larger.

Equation (2.13) for the polymerization rate is not directly usable because it contains a term for the concentration of radicals. Radical concentrations are difficult to measure since they are very low (approximately 10^{-8} molar) and it is therefore desirable to eliminate them from Eq. (2.13). In order to do this, the *steady-state* assumption is made that