专业英语系列教材

Technical English for Material Science

材料专业英语

赵安源 主 编

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前　言

材料的发展水平是人类社会进步的标志之一，新材料技术被视为当今世界六大科技领域之一，材料专业是目前国内外发展最为迅速、技术革新最为活跃的工程领域之一。因此，作为材料专业的学生，除了具备扎实的理论基础和专业知识以外，还要提高专业英语的读、写、译等综合能力。本书编写的主要目的是扩充学生的材料专业的词汇量，提高学生阅读和翻译材料专业英语文献和资料的能力，深化学生对本专业关键技术的认识，了解本学科目前的进展与动向，从而培养具有国际竞争力的技术人才。

《材料专业英语》(Technical English for Material Science)是一本供材料专业的高年级本科生和研究生使用的英语教材。本教材收集了有关高分子材料、无机非金属材料、金属材料、冶金工程和合成材料五大专业领域的最新英语文献，力求从英语语言的角度对材料学科的主要内容进行全面、完整地介绍，使学生能在语言学习的过程中对本专业的新知识、新动向有所了解。

本教材以材料学科的五大专业方向为基础，分为五个部分。每部分设有三课阅读课程和一段补充阅读。阅读课程都设有词汇表、注释和练习项目。

在介绍专业英语的基础上，本教材还在每部分增设了高级阶段的英语语法、书面和口头表达的讲解和训练，以帮助学生在专业英语学习的同时进一步巩固提高英语技能，最终达到可以在材料专业领域全面、熟练地运用英语进行交流的目标。

本书在选材方面既有基础专业知识，也涉及最新国外资料，根据多年教学实践经验尽可能对所选内容进行精心编排，同时考虑到学时的限制，突出了精简的原则。另外，本书结构注重系统性与科学性，内容由浅入深，循序渐进，力求为学生提供丰富的专业知识。本书不仅可以作为材料专业高年级本科生和研究生的教材使用，也可供广大从事材料工程的科技工作者参考。

本书在编写过程中参考了一些国外原版教材和技术性应用文献，在此向这些作者表示感谢。同时，本书的编写得到了华中科技大学出版社的大力支持，在此一并表示感谢。

由于编者水平有限，书中疏漏及错误之处在所难免，敬请广大读者批评指正。

编　者

2009 年 3 月

内 容 提 要

本教材收集了有关高分子材料、无机非金属材料、金属材料、冶金工程和合成材料五大专业领域的最新英语文献，共分为五个部分，每部分由六课组成。每部分设有三课阅读课程和一段补充阅读，阅读课程均设有词汇表、注释和练习项目，力求从英语语言的角度对材料学科的主要内容进行全面、完整地介绍，使学生能在语言学习的过程中对有关本专业的新知识、新动向有所了解。

本书不仅可以作为材料专业的高年级本科生和研究生的教材使用，也可供广大从事材料工程的科技工作者参考。

Contents

PART Ⅰ POLYMERS

Lesson 1 Reading

What Are Polymers?

Polymers are substances containing a large number of structural units joined by the same type of linkage. ① These substances often form into a chain-like structure. Polymers in the natural world have been around since the beginning of time. Starch, cellulose, and rubber all possess polymeric properties. Man-made polymers have been studied since 1832. Today, the polymer industry has grown to be larger than the aluminum, copper and steel industries combined.

Polymers already have a range of applications that far exceeds that of any other class of material available to man. ② Current applications extend from adhesives, coatings, foams, and packaging materials to textile and industrial fibers, elastomers, and structural plastics. Polymers are also used for most composites, electronic devices, biomedical devices, optical devices, and precursors for many newly developed high-tech ceramics.

In agriculture and agribusiness, polymeric materials are used in and on soil to improve aeration, provide mulch, and promote plant growth and health. ③

For medicine, many biomaterials, especially heart valve replacements and blood vessels, are made of polymers like Dacron, Teflon and polyurethane.

As far as consumer science is concerned, plastic containers of all shapes and sizes are light weight and economically less expensive than the more traditional containers. Clothing, floor coverings, garbage disposal bags, and packaging are other polymer applications.

When it comes to industry, automobile parts, windshields for fighter planes, pipes, tanks, packing materials, insulation, wood substitutes, adhesives, matrix for composites, and elastomers are all polymer applications used in the industrial market.

To serve sports well, playground equipment, various balls, golf clubs, swimming pools, and protective helmets are often produced from polymers.

Polymer has a long history of development in human civilization.

As early as the 1500's, British explorers discovered the ancient Mayan civilization in Central America. The Mayans are assumed to be among the first to find an application for polymers, as their children were fond of playing with balls made from local rubber trees.

Then in 1839, Charles Goodyear discovered vulcanization, by combining natural rubber with sulfur and heating it to 270°F. ④ Vulcanized rubber is a polymeric substance that is much more durable than its natural counter part. Its most common use today is in automobile tires.

However, the oldest synthetic plastic is fabricated by Leo Bakeland in 1907. Bakelite's hardness and high heat resistivity made it an excellent choice as an electrical insulator.

1917 found the invention of X-ray crystallography as a method of analyzing crystal structures. Eight years later, this method is used by M. Polanyi to discover the chemical structure of cellulose. This established the fact that polymer unit cells contain sections of long chain molecules rather than small molecular species.

1920 is the year when Staudinger published his classic paper entitled "Uber Polymerization". Publication of this paper heralded a decade of intense research and presented to the world the development of modern polymer theory.

It was in 1927 that the large scale production of vinyl-chloride resins began. This polymeric compound continues to be widely used today to make plumbings, pipes, tiles, and bottles.

The year of 1930 witnessed the invention of polystyrene. This polymeric material is used in videocassettes and other packaging materials. Expanded polystyrene (commonly called Styronfoam) is used in cups, packaging, and thermally insulated containers.

Nylon, another well known polymeric product was produced by Wallace Carothers of the Dupont company at the end of 1938. Nylon, as we know, is a common material used today for such applications as ropes and clothes.

When 1941 arrived, polyethylene found its way into the world, and billions of pounds of both high and low density versions of this material are produced annually for everything from packaging film to piping to toys. ⑤

With the advent of 1970, James Economy developed one of the pioneer moldable high temperature polymers (Ekonol). This polymeric material paved the way for the development of liquid crystal polymers one year later. Ekonol's most common applications occur in electronic devices and aircraft engines.

In 1971, S. Kwolek, who has been awarded more than 37 patents in polymer science, developed keviar. Keviar is a high strength material that can withstand temperatures up to 300℃, and is used in applications such as bulletproof vests, and fireproof garments for firefighting and auto racing.

The epoch-making event in the development of polymer took place in 1976, when the polymer and plastic industry outstripped steel as the most widely used material per unit volume. We now use more plastics than steel, aluminum and copper combined.

Polymers will play a more and more important role in the future. Just as nature has used biological polymers as the material of choice, mankind will choose polymeric materials as the choice material. ⑥ Humans have progressed from the Stone Age, through the Bronze, Iron, and Steel Ages into its current age, the Age of Polymers. An age in which synthetic polymers are and will be the material of choice.

Polymeric materials have a vast potential for exciting new applications in the foreseeable future. Polymer uses are being developed in such diverse areas as: conduction and storage of electricity, heat and light, molecular based information storage and processing, molecular composites, unique separation membranes, revolutionary new forms of food processing and packaging, health, housing, and transportation. Indeed, polymers will play an increasingly important role in all aspects of our life.

The large number of current and future applications of polymeric materials has created a great national need for persons specifically trained to carry out research and development in polymer science and engineering.⑦ A person choosing a career in this field can expect to achieve both financial reward and personal fulfillment.

New Words and Expressions

polymer *n.* 聚合物,高分子,多聚体
be around 来访,出现
starch *n.* 淀粉
cellulose *n.* 纤维素
adhesive *n.* 黏性物,黏合剂
elastomer *n.* 弹性体(合成橡胶,高弹体)
composite *n.* 合成物,复合物
biomedical *adj.* 生物医学的
optical *adj.* 光学的,眼睛的,视觉的
precursor *adj.* 先驱,前导,先行者
ceramics *n.* 制陶术
aeration *n.* 充气(松砂,分解)
vinyl-chloride resin *n.* 氯乙烯树脂
tile *n.* 砖瓦,瓷砖
polystyrene *n.* 聚苯乙烯
styronfoam *n.* 聚苯乙烯泡沫塑料
insulate *v.* 使绝缘,使隔热
nylon *n.* 尼龙
polyethylene *n.* 聚乙烯
moldable *adj.* 可塑的
mulch *n.* 护盖物,护根,根篱
dacron *n.* 涤纶
teflon *n.* 特氟纶,聚四氟乙烯(绝缘材料)
polyurethane *n.* 聚亚安酯
matrix *n.* 基质
vulcanization *n.* 橡胶的硬化,硫化
counterpart *n.* 相似之物
synthetic *adj.* 合成的,人造的
fabricate *v.* 制造,建造,装配
bakelite *n.* 人造树胶,胶木
crystallography *n.* 结晶学
herald *n.* 先驱者,前锋
liquid crystal 液晶
keviar *n.* 纤维 B,合成纤维
auto racing 赛车
outstrip *v.* 超过,跑过
unit volume 单位体积
choice material 精选的材料
membrane *n.* 薄膜,膜皮,羊皮纸

Notes

①Polymers are substances containing a large number of structural units joined by the same type of linkage.

聚合物是指由相同方式结合的大量结构单元组成的物质。

②Polymers already have a range of applications that far exceeds that of any other class of material available to man.

聚合材料应用的范围已远远超过人类已知的其他任何材料。

③In agriculture and agribusiness, polymeric materials are used in and on soil to improve aeration, provide mulch, and promote plant growth and health.

在农业及和农业相关的产业中,聚合材料常被用在土壤中或土壤上以改善土壤的通气状况,为土壤提供遮盖并促进农作物的健康生长。

④Then in 1839, Charles Goodyear discovered vulcanization, by combining natural rubber with sulfur and heating it to 270°F.

接着在 1839 年,查尔斯·古德伊尔通过把天然橡胶和硫结合并加热至 270 华氏度,发现了橡胶的硬化方法。

⑤When 1941 arrived, polyethylene found its way into the world, and billions of pounds of both high and low density versions of this material are produced annually for everything from packaging film to piping to toys.

1941 年，聚乙烯出现在世界上。从此，每年有几十亿磅这种密度高、低不一的材料生产出来，用于从包装、管道到玩具制造。

⑥Just as nature has used biological polymers as the material of choice, mankind will choose polymeric materials as the choice material.

就像大自然选择生物高分子材料做精选材料一样，人类也选择聚合材料作为精选材料。

⑦The large number of current and future applications of polymeric materials has created a great national need for persons specifically trained to carry out research and development in polymer science and engineering.

高分子材料当前和未来的大量使用提出了对能胜任聚合物研究开发并训练有素的人员的需求。

Exercises

Ⅰ. Comprehension questions.

1. Polymers are substances made up of ________.
   A. many different types of linkage
   B. units linked together in the same way
   C. the same linkage
   D. structures of the same type
2. Which is NOT true according to the passage?
   A. Of all the materials, polymers have the most uses.
   B. Polymers can be used for adhesives, coatings and foams.
   C. Automobile industry depends on polymers alone.
   D. Polymers are often used to make protective materials for sports.
3. Which of the following is TRUE?
   A. Rubbers are found in the Mayan civilization.
   B. Automobile tires are commonly vulcanized before use.
   C. M. Polanyi discovered X-ray crystallography.
   D. Vinyle-chloride resin was first produced in 1927.
4. Polystyrene is used ________.
   A. to make video tapes
   B. for expansion of polymers
   C. to make Styronfoam for packaging and heat insulation
   D. in containerization for transporting cups
5. Eknol is a polymeric material that can be ________.
   A. made in molds
   B. used in the places with much heat
   C. found in liquid crystal
   D. fixed in electric devices and aircraft engines

6. What important event happened in 1976 about the development of polymer?
   A. For the first time, more polymer materials were made than steel.
   B. Polymers and plastics were widely used.
   C. Plastics and metal materials were combined.
   D. Polymers made an epoch in history.
7. Polymers will be ________ in the future.
   A. in an age of stone, bronze, iron and steel
   B. chosen by mankind
   C. the choicest material
   D. used as the biological material of choice
8. The fast development of polymer materials ________.
   A. can make everybody rich
   B. will make polymer a financial material
   C. need more people to think about personal fulfillment
   D. creates opportunities for people to succeed

Ⅱ. Translate the following sentences into Chinese.

1. Polymers in the natural world have been around since the beginning of time. Starch, cellulose, and rubber all possess polymeric properties.
2. Current applications extend from adhesives, coatings, foams, and packaging materials to textile and industrial fibers, elastomers, and structural plastics.
3. When it comes to industry, automobile parts, windshields for fighter planes, pipes, tanks, packing materials, insulation, wood substitutes, adhesives, matrix for composites, and elastomers are all polymer applications used in the industrial market.
4. The Mayans are assumed to be among the first to find an application for polymers, as their children were fond of playing with balls made from local rubber trees.
5. Humans have progressed from the Stone Age, through the Bronze, Iron, and Steel Ages into its current age, the Age of Polymers. An age in which synthetic polymers are and will be the material of choice.
6. A person choosing a career in this field can expect to achieve both financial reward and personal fulfillment.

Word Study

1. contain

   vt. 包含,容纳

   1) Whisky contains a large percentage of alcohol.
      威士忌的酒精含量极高。
   2) Does it contain carrot?
      里面有胡萝卜吗?
   3) The resolution must contain a section expounding Mao Zedong Thought.
      决议稿中阐述毛泽东思想的这一部分不能不要。
   4) A line on a form that may contain delimiters, but does not contain other characters.

可以包含定界符但不包含其他字符的一种格式行。

2. exceed

vt. 超过，超越

The demand for fish this month exceeds the supply.

本月的鱼市供不应求。

vi. （在数量、质量上）突出，领先

In the Olympic Games Americans excelled in basketball.

在奥运会上，美国在篮球方面领先。

3. assume

vt. 假设，假装，采取

1) We can't assume anything in this case.
在这种情况下我们不可能做出假设。

2) He assumed a look of innocence.
他装出一副天真无邪的样子。

3) We assumed a new method.
我们采取了一种新方法。

4. witness

n. 目击者，证人，证词，证据

1) She was a witness of the incident.
她是事件的目击者。

2) He gave witness on behalf of an accused person.
他为被告作证。

vt. 目击，作证，证明，表示，说明

1) I witnessed the accident.
我亲眼目睹了这场事故。

2) No one could witness that he was present.
没有人能证明他在现场。

3) Severe damage witnessed the destructive force of the storm.
严重的损坏表明了这场暴风雨巨大的破坏力。

5. pave

vt. 铺，为……铺平道路

1) The street is paved with asphalt.
街道被铺上柏油。

2) I do hope the treaty will pave the way to peace in the Middle East.
我真希望这个条约将为中东的和平铺平道路。

6. outstrip

vt. 做得比……更好，（在赛跑等中）超过

1) That manufacturer outstripped all his competitors in sales last year.
那个制造商家去年的销售量超过了所有竞争对手。

2) Demand is outstripping current production.
现在需求逐渐超过了生产能力。

3) He can outstrip his friend both in sports and in studies.

他能在体育和学习方面胜过他的朋友。

7. diverse

adj. 不同的，多种多样的

1) Her interests are very diverse.
她的兴趣非常广泛。

2) The program deals with subjects as diverse as pop music and Beijing Opera.
节目涉及从流行音乐到京剧这样多种多样的形式。

3) Chinese society will become more diverse.
中国社会将变得更多样化。

8. achieve

vt. 取得，获得，实现，达到

1) They achieved some victories despite these setbacks.
尽管受到这些挫折，他们还是取得了一些胜利。

2) You will achieve your ambition if you work hard.
如果你努力，你的抱负是可以实现的。

Lesson 2 Reading

Scientific Principles of Polymers

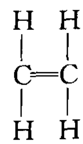
The field of polymers is so vast and the applications so varied, that it is important to understand how polymers are made and used. Since there are over 60 000 different plastics vying for a place in the market, knowledge of this important field can truly enrich our appreciation of this wonder material. Companies manufacture over 30 million tons of plastics each year, and spend large sums on research, development, and more efficient recycling methods. Below we learn some of the scientific principles involved in the production and processing of these fossil fuel derived materials known as polymers. ①

Polymerization Reactions

The chemical reaction in which high molecular mass molecules are formed from monomers is known as polymerization. ②There are two basic types of polymerization, chain-reaction (or addition) and step-reaction (or condensation) polymerization.

Chain-Reaction Polymerization

One of the most common types of polymer reactions is chain-reaction (addition) polymerization. This type of polymerization is a three step process involving two chemical entities. The first, known simply as a monomer, can be regarded as one link in a polymer chain. It initially exists as simple units. In nearly all cases, the monomers have at least one carbon-carbon double bond. Ethylene is one example of a monomer used to make a common polymer.



Ethylene

The other chemical reactant is a catalyst. In chain-reaction polymerization, the catalyst can be a free-radical peroxide added in relatively low concentrations. A free-radical is a chemical component that contains a free electron that forms a covalent bond with an electron on another molecule. The formation of a free radical from an organic peroxide is shown below.

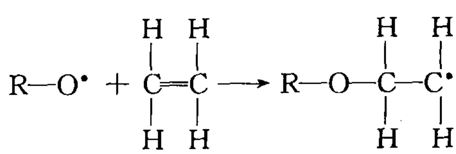
$$R—O—O—R \longrightarrow R—O^{\bullet} + R—O^{\bullet}$$

with(•)representing the free electron

In this chemical reaction, two free radicals have been formed from the one molecule of R_2O_2. Now that all the chemical components have been identified, we can begin to look at the polymerization process.

Step 1: Initiation

The first step in the chain-reaction polymerization process, initiation, occurs when the free-radical catalyst reacts with a double-bonded carbon monomer, beginning the polymer chain. The double carbon bond breaks apart, the monomer bonds to the free radical, and the free electron is transferred to the outside carbon atom in this reaction. [3]



Step 2: Propagation

The next step in the process, propagation, is a repetitive operation in which the physical chain of the polymer is formed. The double bond of successive monomers is opened up when the monomer is reacted to the reactive polymer chain. The free electron is successively passed down the line of the chain to the outside carbon atom.

$$\underbrace{R—O—CH_2—CH_2^{\bullet}}_{\text{Propagating polymer chain}} + \underbrace{CH_2{=}CH_2}_{\text{Monomer}} \longrightarrow \underbrace{R—O—CH_2—CH_2—CH_2—CH_2^{\bullet}}_{\text{New polymer chain}}$$

This reaction is able to occur continuously because the energy in the chemical system is lowered as the chain grows. Thermodynamically speaking, the sum of the energies of the polymer is less than the sum of the energies of the individual monomers. Simply put, the single bonds in the polymeric chain are more stable than the double bonds of the monomer.

Step 3: Termination

Termination occurs when another free radical ($R—O^{\bullet}$), left over from the original splitting of the organic peroxide, meets the end of the growing chain. [4] This free-radical terminates the chain by linking with the last $CH_2^{\bullet}$ component of the polymer chain. This reaction produces a complete polymer chain. Termination can also occur when two unfinished chains bond together. Both termination types are diagrammed below. Other types of termination are also possible.

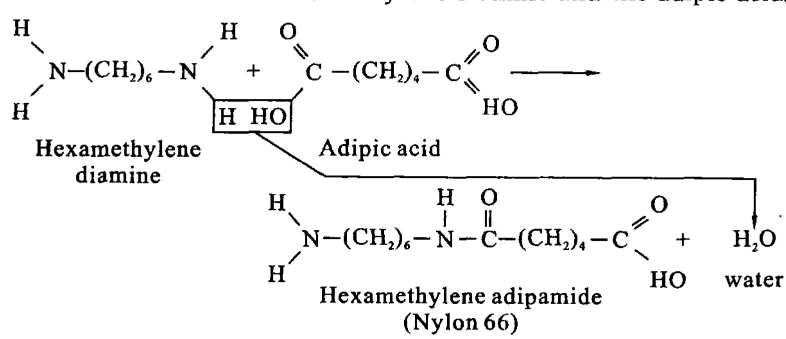
$$\underbrace{R-O-CH_2-CH_2-CH_2-CH_2^{\bullet}}_{\text{Propagating polymer chain}} + \underset{\substack{\uparrow \\ \text{left over} \\ \text{free-radical}}}{R-O^{\bullet}} \rightarrow \underbrace{R-O-CH_2-CH_2-CH_2-CH_2-O-R}_{\text{Completed polymer chain}}$$

$$\underbrace{R-O-CH_2-CH_2^{\bullet} + R-O-CH_2-CH_2^{\bullet}}_{\text{Propagating polymer chains}} \longrightarrow \underbrace{R-O-CH_2-CH_2-CH_2-CH_2-O-R}_{\text{Completed polymer chain}}$$

This exothermic reaction occurs extremely fast, forming individual chains of polyethylene often in less than 0.1 second. The polymers created have relatively high molecular weight. It is not unusual for branches or cross-links with other chains to occur along the main chain.

Step-Reaction Polymerization

Step-reaction (condensation) polymerization is another common type of polymerization. This polymerization method typically produces polymers of lower molecular weight than chain reactions and requires higher temperatures to occur. Unlike addition polymerization, step-wise reactions involve two different types of di-functional monomers or end groups that react with one another, forming a chain. Condensation polymerization also produces a small molecular by-product (water, HCl, etc.). Below is an example of the formation of Nylon 66, a common polymeric clothing material, involving one each of two monomers, hexamethylene diamine and adipic acid, reacting to form a dimer of Nylon 66. This polymer is known as nylon 66 because of the six carbon atoms in both the hexamethylene diamine and the adipic acid.

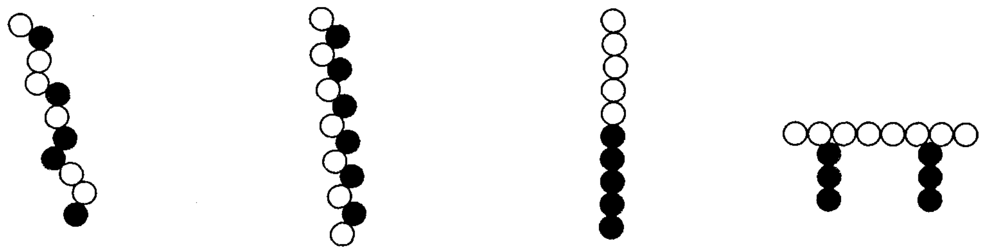


At this point, the polymer could grow in either direction by bonding to another molecule of hexamethylene diamine or adipic acid, or to another dimer. As the chain grows, the short chain molecules are called oligomers. This reaction process can, theoretically, continue until no further monomers and reactive end groups are available. The process, however, is relatively slow and can take up to several hours or days. Typically this process breeds linear chains that are strung out without any cross-linking or branching, unless a tri-functional monomer is added. ⑤

Polymer Chemical Structure

The monomers in a polymer can be arranged in a number of different ways. As indicated above, both addition and condensation polymers can be linear, branched, or cross-linked. Linear polymers are made up of one long continuous chain, without any excess appendages or attachments. Branched polymers have a chain structure that consists of one main chain of molecules with smaller molecular chains branching from it. A branched chain-structure tends to lower the degree of crystallinity and density of a polymer. Cross-linking in polymers occurs when primary valence bonds are formed between separate polymer chain molecules. [6]

Chains with only one type of monomer are known as homopolymers. If two or more different types of monomers are involved, the resulting copolymer can have several configurations or arrangements of the monomers along the chain. The four main configurations are depicted in Figure 1. 1.



(a)random copolymer (b)alternating copolymer (c)blok copolymer (d)graft copolymer

Figure 1. 1 Copolymer configurations

Polymer Physical Structure

Segments of polymer molecules can exist in two distinct physical structures. They can be found in either crystalline or amorphous forms. Crystalline polymers are only possible if there is a regular chemical structure (e. g. , homopolymers or alternating copolymers), and the chains possess a highly ordered arrangement of their segments. Crystallinity in polymers is favored in symmetrical polymer chains, however, it is never 100%. These semi-crystalline polymers possess a rather typical liquefaction pathway, retaining their solid state until they reach their melting point at T_m. [7]

Amorphous polymers do not show order. The molecular segments in amorphous polymers or the amorphous domains of semi-crystalline polymers are randomly arranged and entangled. Amorphous polymers do not have a definable T_m due to their randomness. At low temperatures, below their glass transition temperature (T_g), the segments are immobile and the sample is often brittle. As temperatures increase close to T_g, the molecular segments can begin to move. Above T_g, the mobility is sufficient (if no crystals are present) that the polymer can flow as a highly viscous liquid. The viscosity decreases with increasing temperature and decreasing molecular weight. There can also be an elastic response if the entanglements can not align at the rate a force is applied (as in silly putty). This material is then described as visco-elastic. In a semi-crystalline polymer, molecular flow is prevented by the portions of the molecules in the crystals until the temperature is above T_m. At this point a visco-elastic material forms. These effects can most easily be seen on a specific volume versus temperature graph (Figure 1. 2).

In the area between T_g and T_m, the semi-crystalline polymer is a tough solid. The amorphous material changes to a viscous liquid after T_g. This is when the material can be easily deformed.