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ON RESEARCH INTO THE EPOXY POLYMER MOLECULAR STRUCTURE

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Different materials are very important for people existence and activity. Every material determines the stage of human activity. Looking at the whole period of mankind development one may note that practically every century is characterized by a material. When the homo sapiens only started to make the implements, he took the materials which were easy of access. First, it was stone. People used the stone implements for a long time, and it was the Stone Age. The time was flying, the people became more and more resourceful and learned to get and work up copper. People wanted to find or create new materials which would be harder, and they managed to do it. The Bronze Age had come, and then the Iron Age. Mankind evolved, became cleverer, the science appeared, new materials and elements were found. The people have found the means of using the silicon. The devices based on silicon were not simple; a real scientific breakthrough was made by the mankind. The Silicon Age is called the Age of Electronics.

We live in the 21st century and we can say with confidence that the main materials developing now are plastics. More and more the people need hard and light materials, which could be made without using the mineral products and natural recourses and at the same time these materials have to be as strong as steel.

The topicality of the problem

The problem of creating hard polymer is urgent for aviation, space technologies and everyday life. Such material is needed everywhere, where such properties like lightness, durability and solidity are wanted.

Today this problem is solved by creating composite materials on the basis of resins with different fillers. [Н. С. Наумкин. Исследование композиционных материалов на основе эпоксидных полимеров с наноалмазами. Диссертация на соискание степени магистра. Красноярск. 2008. 42 с.]

Epoxy resin is used like a matrix and as reinforcing elements the fibers and dispersive powders from different materials are used. A disadvantage of creating a composite material is the complexity of its production and making parts of it. It is necessary to make dispersive powder, fine grain and only then to produce the part. For manufacturing different types of parts from composite materials with reinforcing filaments it is necessary to produce different devices for stowage and winding these fibers.

In its turn, epoxy polymers are the most durable polymer materials, which are produced in the process of chemical reactions. The working strength of epoxy matrix is one degree higher than it is observed in practice. This is due to the fact that the bond of polymer molecules is a covalent bond. The covalent bond is the strongest bond. The problem is how the strength which is present on the micro level, the level of molecules, can be carried over to the macro scale [И. А. Комельков. Исследование дефектов структуры эпоксидного полимера методом ИК-спектроскопии на основе анализа СО колебаний. Дипломная работа. Красноярск. 2010. 68 с.] [А. Ю. Дрокин. Исследование дефектов структуры олигомера ЭД-22 методом ИК-спектроскопии на основе анализа О-Н колебаний. Дипломная работа. Красноярск. 2010. 70 с.].

Chemical reaction

Epoxy polymer is the compound of the epoxy resin and a curing agent. The structure of an epoxy resin molecule is very complicated. It consists of the epoxy groups at the end of

the molecule, hydroxyl, carboxyl groups and benzene rings (Fig. 1). The molecule of the curing agent includes carboxyl groups.

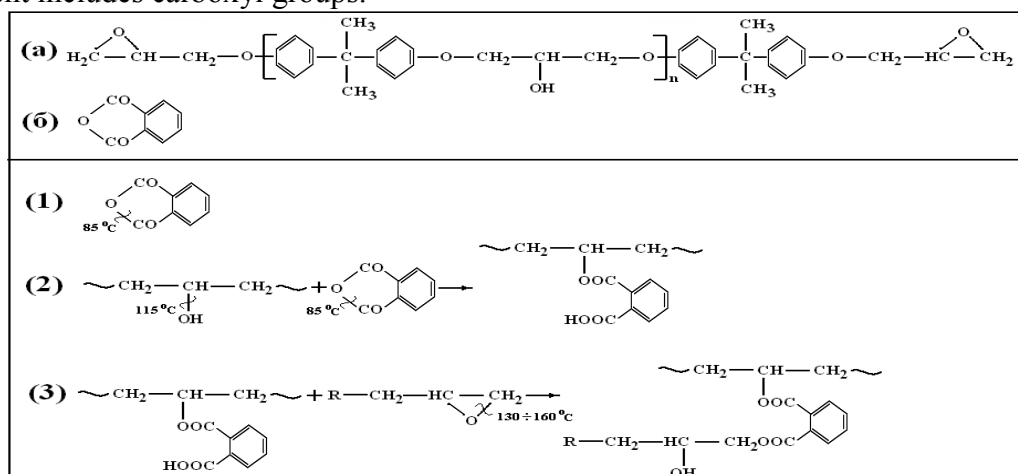


Fig. 1. The chemical reaction of polymerization:

a) epoxy resin molecule; b) curing agent molecule; 1) the first stage of polymerization; 2) the second stage of polymerization; 3) the third stage of polymerization.

On the first stage there is the left ring-opening of the curing agent molecule. On the second stage the hydroxyl groups of the epoxy resin react with the curing agent. There are the bond breakage and new bonding. On the third stage of polymerization the new carboxyl groups react with epoxy groups. It is considered ideal, if every curing agent molecule unites with molecules of epoxy resin as is shown in Fig. 1. But in practice we observe an opposite situation. There are different defects like non-reacted molecules of resin or curing agent [Н.С. Наумкин, А.А. Иваненко, Н.П. Шестаков, В.Е. Редькин, А.Ю. Дрокин, И.А. Комельков. Исследование композиционных материалов на основе эпоксидных полимеров с наноналмазами.].

Viscosity of the mixture increases quickly with the growth of the molecular block mass. The edge of big molecular blocks is contiguous to each other, but their movements are complicated. So the big molecular blocks can't be brought together, and the reactive groups are located on such distance that the bonding is impossible. The growth of polymer blocks stops, and the excess epoxy molecules and small molecular blocks stay on the edge (Fig. 2). [И. А. Комельков. Исследование дефектов структуры эпоксидного полимера методом ИК-спектроскопии на основе анализа СО колебаний. Дипломная работа. Красноярск. 2010. 68 с.] [А. Ю. Дрокин. Исследование дефектов структуры олигомера ЭД-22 методом ИК-спектроскопии на основе анализа О-Н колебаний. Дипломная работа. Красноярск. 2010. 70 с.]

The material with the hardness of steel should consist of only one such molecular block.

The method of gradient temperature

There were many experiments for understanding the nature of the appearance of these defects in the structure. The investigation was carried out to determine the optimal concentration and it became clear, that the concentration influenced the appearance of defects in a lesser degree. The degree of the defects appearance is influenced by the method of polymer creating. The recent experiments showed the polymerization should take place in the close volume, otherwise the molecules of the curing agent emit. So it results in appearance of defects such as the epoxy resin molecules.

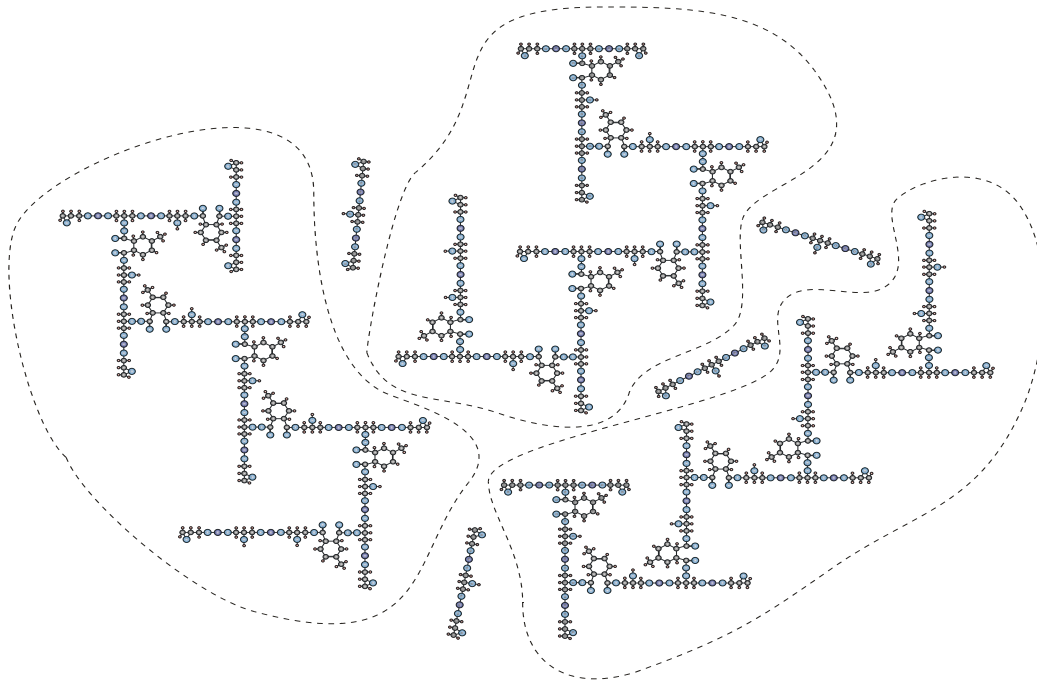


Fig.2. The molecular blocks and defects

Now we are testing the theory of gradient heating and we hope that we have found a method of creating the epoxy polymer without defects. We consider that the polymerization should be going on in the plane where the molecules could react with each other without intervention of other molecules.

It takes place when the sample passes by the temperature gradient with a very low velocity, approximately 2 millimeters per hour. We need to have a very straight tube and it must not bend sideward to the walls of the device.

We have obtained some samples as a result of using the gradient temperature method. We are investigating their physical and mechanical properties and found out that their spectra different the samples spectra obtained with the traditional method.