SORPTION OF NANOPARTICLES AND PROTECTIVE MATERIALS

Redko Ya.V.
Kiev National University of technology and design

The general theory of creation nanoparticle dispersions, the heterocoagulation of nanoparticles on the surface are qualitative in nature, which does not allow to determinine the parameters of nanotechnology: creating nanodispersion of the electroconductive and magnetic particles and their sorption on the fibrous material to form a layer which is resistant to external influences.

A special case of conducting polymers is the synthesis of polyaniline on the fiber with the creation of conductive fiber materials using the heterocoagulation mechanism in dying process of oxidative condensation of aniline in the presence of surface-active substances [1, 2].

Increased interest in the nano-sized iron-oxide materials related to their application in various fields of engineering and medicine. Main requirement for these materials is the high enough values of magnetization, which depend not only on particle size but also on their phase composition, especially on the presence of ferromagnetic phase. Getting of nanosized particles of iron oxide on the fibrous material in the process of dyeing is possible by the mechanism of heterocoagulation [3, 4], which significantly expands the range of their practical application, and also increases the number of types of textiles with protective properties.

The particle size distribution was determined using Mastersizer 2000 (Malvern, UK) with appropriate software, which includes the Mie theory. Using the device allows to obtain the size distribution curves as a function of the numerical fraction of particles according to their size.

Durability of the connection of the colloidal particles with the surface depends on their size, in the limit, the maximum interaction of the surface of fibers with nano-sized particles of the dispersed phase. Fig. 1 shows the distribution curves of particle size of polyaniline as a function of the numerical fraction of particles by their size.

The investigated dispersion refers to nanosystems: particles with size 60 ÷ 200 nm constitute about 80%. With an average size of ca. 100 nm.

As a result, the process of diffusion of polyaniline particles deep into the fibers is impossible [1, 2], and the basic mechanism of dyeing in this case is heterocoagulation of nanoparticles on the fiber surface.

The oxidation of aniline to polyaniline in the presence of a polyamide textile material and a surfactant in the range 5 ÷ 15 minutes, depends on the concentration of aniline, which is not enough for molecular diffusion of aniline in the polyamide textile material (with subsequent oxidation) [2].

This is an additional evidence of the possibility of making of electroconductive fibers on the basis of polyaniline with the use of heterocoagulation mechanism, in the absence of the dye sorption stage or semiproduct in a molecular form. In favor of heterocoagulation on the fiber surface is also indicated by the absence of changes in physical and mechanical properties of polyamide textile material also [3].

As the fibrous material the knitted polyamide fabric and polyamide multifilament yarn were used. Nanodispersion of magnetite obtained by precipitation of iron salts (Fe (II) and Fe (III)) by solution of aqueous ammonia at pH 10 in the presence of polyamide fiber material and the surfactant in the dyeing bath using mechanism of heterocoagulation to obtain textile magnetic materials [3, 4].

To achieve the objectives we have used the classical methods of chemical technology of textile materials, modern method of X-ray diffraction analysis, developed a method of determining the value of the saturation magnetization dying fibrous material by magnetite nanoparticles.

To investigate the question of magnetite phase composition of the compounds obtained on the polyamide fiber materials using method of X-ray diffraction analysis, with which the samples of magnetite that synthesized in the presence of the cationic-active surface active substances, respectively (Fig. 2). In the diffractograms of the samples the peaks in the angle 10 – 35 degr., were absent, which is usually observed for the phase maghemite. It was established that for both samples the average crystallite size is around 10 – 12 nm. Thus, the method of X-ray diffraction analysis showed the phase composition and determined the average crystallite size of magnetite.

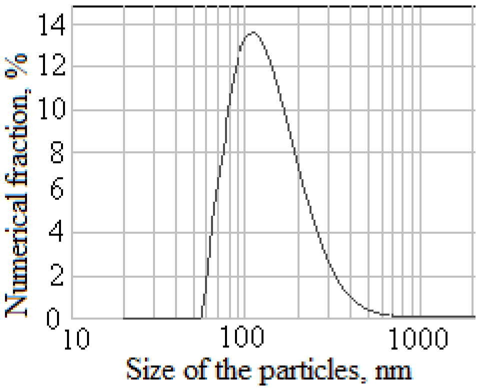

Fig. 1. Differential curve of the polyaniline particle size distribution.

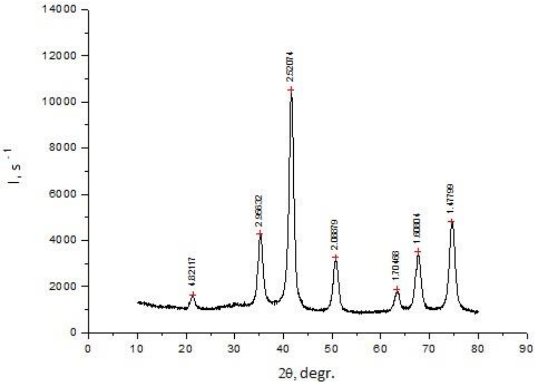

Fig. 2. Diffraction pattern of magnetite synthesized in the presence the cationic-active SAS (2).

The action of surfactants in the dye bath is multifaceted: first, the surfactant affects the dispersion formation of the poorly water-soluble aniline in the dye bath, second, it influences the dispersed structure of polyaniline, which is formed during synthesis, and third – due to the adsorption on the surface of the fiber it changes the possibility of heterocoagulation process and the durability of the interaction of the dispersed phase with the surface of the fibrous material.

In this regard, we investigated: the influence of anion surfactants on the sorption of polyaniline nanoparticles on the surface of the fibrous material during the heterocoagulation process; the influence of the anion surfactants on the value of the resistance of polyamide knitted fabric; the influence of the concentration of different types of surfactants on the sorption of polyaniline nanoparticles on the surface of fibrous materials.

We found a linear dependence of the conductivity of fiber material coated on the number of deposition stages by sorption of polyaniline nanoparticles in the presence of different types of surfactants which suggests that the oppositely charged nanoparticles of polyaniline are stabilized by the alternating anionactive and cationactive surfactants to form the electrically conductive layers through the implementation of the self-assembly of the polyaniline nanoparticles, by the forming of a multilayer coating on the surface of the polyamide fiber material with forming the stable ordered nanostructures on the surface of the fibrous material, and on the other – can easily change a form of self-organization when the parameters of the process.

Present method of the obtaining of the conductive fibrous material allows us to achieve a sufficient resistance to wet and dry rubbing of the colored fibrous materials, provide a specific conductivity of fibrous material, which is $1 \cdot 10^{-2} \div 1 \cdot 10^{3}$ Sm/m [4], and give up the use of carbon and metallic fibers, which are used in the manufacture of complex processes associated with the use of special equipment.

Thus developed conductive textile materials can be used for making special clothing to protect personnel from strong electromagnetic fields or electrostatic voltage; clothing that has anti-static properties; warm clothes; antistatic and reinforcement adding to the fabric and polymers as a textile neutralizer of static electricity.

One of the methods of obtaining of nanosystems is a deposition of dispersed particles of insoluble compound by the synthesis in a liquid medium. In this case it is necessary to stop the formation of the dispersed phase at the stage of the formation of nanoparticles. Surfactant affects the synthesis of the magnetite dispersion structure which is formed by adsorption and on the surface of the fiber which affects the possibility of the heterocoagulation process and affects the durability of interaction of nanoparticles with the surface of fibrous material.

For the classical heterocoagulation which is characterized by a deposition of the oppositely charged particles due to the neutralization of the charges at interaction of the particles. In an alkaline medium (pH> 7) polyamide fiber has a negative ξ - potential, the magnetite particles are dispersed, with the dispersion stabilization of cationic surfactant (alkamon) – positive ξ - potential.

Therefore, the synthesis of magnetite at a pH of about 10 ÷ 11 in the presence of cationic SAS positively charged particles of magnetite deposited on the negatively charged surface of the fiber due to the electrostatic interaction of nanoparticles with the surface of the polyamide fiber material by the heterocoagulation mechanism that is supported by the particular experiment. Pretreatment of the polyamide fiber material by solutions of electrolytes, in principle, could facilitate disruption of the sorption stability of the magnetite dispersion and increases the amount of magnetite deposited by the heterocoagulation mechanism on the polyamide fiber.

The use of a cationic surfactant leads to the achievement of the maximum number of nanoparticles on the fibrous material, which corresponds to the value of optical density (D), equal to 0.14 (which is 12.1% by weight of the polyamide fiber material) in contrast to the application of anionic surfactant in the synthesis of nanoparticles under similar conditions (D = 0.1) [3, 4].

This data can be explained by the fact that the magnetic properties of pre-treated polyamide fiber material are determined by not only the quantity of nanosynthesized magnetite in the dyeing bath in the presence of cationic surfactants and by the heterocoagulation magnetite nanoparticles on the polyamide fiber material (concentration of magnetite nanoparticles on the fiber), but also the distribution of nanoparticles on the surface of the fibrous material.

Based on new principles, fundamentals of nanotechnology create inexpensive and simple but effective and convenient methods of making of materials that protect the personnel of military units and military communications and microwave communications with newly developed magnetic textile materials, with the saturation magnetization which is 2÷10 $A \cdot m^2/kg$ [4]. Such textile materials can be produced using existing materials in Ukraine, as well as the classical technology and finishing production equipment which will be widely used due to obtaining colors resistant to various influences

.

References

1. Пат. 102413 (UA), МПК D06M 15/00. Спосіб отримання електропровідного волокнистого матеріалу / Редько Я.В., Романкевич О.В. – № a201106310; Заявл. 19.05.2011; Опубл. 10.07.2013, Бюл. № 13.
2. Redko Ya. The applying of nanotechnologies for obtaining electroconductive textile materials with using of the geterocoagulation mechanism / Ya.V. Redko, O.V. Romankevich // Scientific basis of modern technology: experience and prospects. Monograph: edited by Shalapko Y.I. and Dobrzanski L.A. – 2011. – P. 440–450.
3. Романкевич О.В., Редько Я.В., Брик А.Б. Гетерокоагуляция дисперсии магнетита на полиамидном волокнистом материале / О.В. Романкевич // Дизайн. Материалы. Технологии. – Санкт-Петербург, Изд-во Санкт-Петербуржского национального университета технологий и дизайна, 2012. – № 5 (25).– С. 45–49.
4. Редько Я.В. Дослідження магнітних властивостей волокнистих матеріалів, що містять наночастинки магнетиту / Я.В. Редько, О.В. Романкевич, О.Б. Брик // Вісник КНУТД – 2013. – № 1 (69). – С. 111-117.