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SCIENTIFIC RESEARCH OF THE FORMATION OF FRACTAL STRUCTURAL INTERPOLYMERIC POLYANILINE COMPOUNDS

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Abstract:
The physical and mechanical properties of fractal-structural interpolymer complexes and compositions of polyaniline with polyacids have been obtained and investigated. The kinetics of formation and physics – the chemical properties of fractal-structural interpolymer materials of polyanilines with polyacids are studied. These materials have high electrical conductivity and adhesion.

Keywords: Fractal structural, polymer, interpolymer, polyaniline, composite, electrical conductivity.

1.INTRODUCTION.

Polyaniline is an organic high molecular weight semiconductor representative of a relatively recently discovered class of electrically conductive polymers. Among all conductive polymers, PANI demonstrates exceptional properties due to its environmental stability, redox reversibility, high electrical conductivity and ease of synthesis, which can be found application in electronic devices and devices.

2.METHODS AND RESEARCH.

Polyaniline possesses controlled electronic conductivity in the range of 10^{-10}–10^{1} Siemens cm^{-1} in combination with ionic conductivity, redox activity, electro- and solvatochromism, nonlinear optical properties, and paramagnetism. In addition to this, the polymer is non-toxic, resistant to aggressive chemical environments, has high thermal stability and low cost. Due to the unique set of properties and high stability, PANI was the first among electrically conductive polymers to be used in practice [1]. The PANI macromolecule is a polymer chain in which benzene rings and nitrogen atoms alternate with each other. Polyaniline depending on the oxidation state and degree of protonation exhibits both the properties of an insulator and a conductor. Only PANI in the form of an emeraldine salt has high conductivity. The transition to this conducting form of PANI is possible as a result of redox or acid-base doping.

3.RESULTS AND DISCUSSION.

PANI is a unique polymer in which the electrically conductive emeraldine and pernigraniline forms of the polymer can be transformed into a non-conducting state in two different ways. Polyanilines and interpolymer complexes based on them can be synthesized both by a chemical method and in the process of electrochemical polymerization of aniline on a mother liquor in the electrodes of an electrochemical cell [2]. Electrochemical methods obtained electrically conductive interpolymer complexes of polyanilines with polyacids, have significant physics-chemical properties in comparison with chemically synthesized compounds [3]. Especially as uniformity of samples, strong adhesion, high electrical conductivity, chemical resistance, etc. However, despite the numerous research works in the field of the synthesis of polyanilines and interpolymer complexes with polyacids, a unified theory of the polymerization mechanism has not yet been clarified. In this regard, to understand the mechanism of the processes of electrochemical synthesis of the interpolymer complex and polyanilines, it may be useful to study the conditions for the synthesis of fractal-structural compounds based on polyanilines and polyacids. Fractal objects are objects that have the property of scale invariance or self-similarity. These include, in particular, interpenetrating interpolymer complexes, polymer gels, composite polymer materials. In particular, the fractally diffusely controlled aggregation process, the particles of polyaniline or poly-ortho-toluidine macromolecules wander in the mother liquor of the polyacid, then, as a result of interaction with the polyacid chains, they form fractal - structural interpolymer complexes of polyanilines with polyacids. In this process, the particle wanders along the polymer chain randomly to a seed particle placed in the center of it, and after finding the polyacid chain, the polyaniline interacts with the polyacid immediately. Then the process is repeated for the next particle, etc. As a result, fractal structural interpolymer complexes are formed, which are shown in Fig. 1-2.

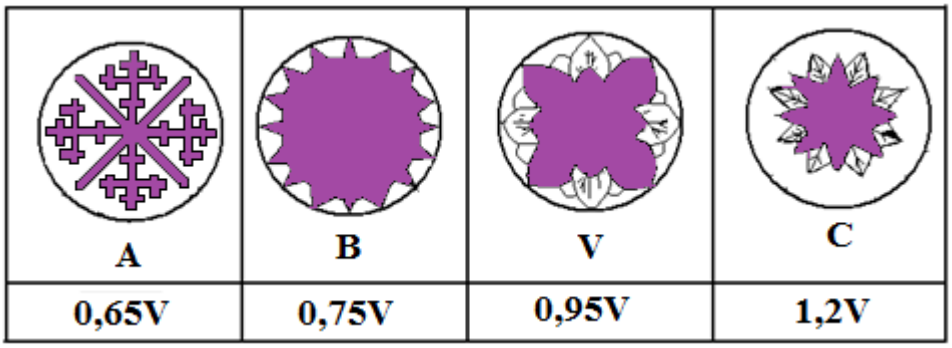

Fig. 1. Fractal-structural interpolymer complexes of polyaniline with linear polyacids under electrochemical conditions. (a-0,65 V, b-0,75 V, c-0,95 V, d-1,2 V) electric current potentials. PANI/PAC

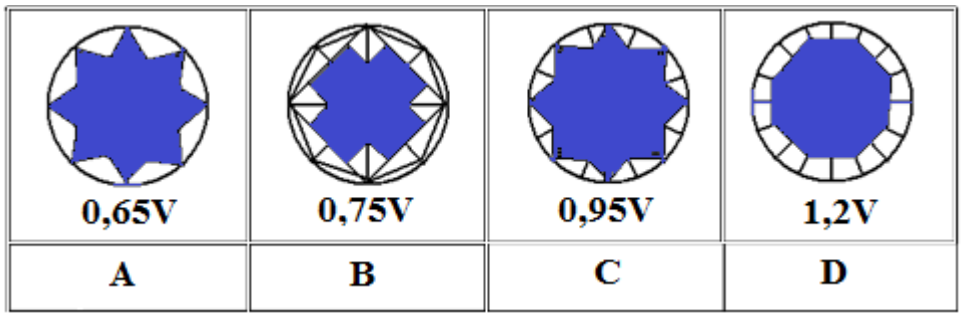

Fig. 2. Fractal-structural interpolymer complexes of poly-ortho-toluidine with linear polyacids obtained (a-0,65 V, b-0,75 V, c-0,95 V, e-1,2 V) electric current potentials

It should be especially noted that during the interaction of polyanilines with polyacids, the formation and growth of fractal structural interpolymer complexes begins from the central part of the electrochemical cell only in the horizontal direction. The form of the resulting fractal-structural interpolymer complexes depends on the applied voltage potential of the synthesis current. The resulting interpolymer complexes and compositions have increased electrical conductivity compared to a conventional electrochemical cell. When studying the physicochemical and electromechanical properties of interpolymer complexes of polyaniline with polyacids, the following was revealed: the fractal structural interpolymer complex of polyaniline with polyacrylic acid has an electrical conductivity of $3{,}8\cdot10^{4}$ $om^{-1}\cdot cm^{-1}$ compared to the electrochemical synthesis of $2{,}8\cdot10^{-2}$ $om^{-1}\cdot cm^{-1}$. the same interpolymer complex in a conventional electrochemical cell. Interpolymer complexes of poly-ortho-toluidine with polyacrylic acid obtained under normal conditions of electrochemical synthesis have an electrical conductivity of $2{,}2\cdot10^{-2}$ $om^{-1}\cdot cm^{-1}$. Under conditions of fractal structural formation, the P-O-TOD/PAK interpolymer complex has an electrical conductivity of $3{,}6\cdot10^{4}$ $om^{-1}\cdot cm^{-1}$. This rather high electrical conductivity can be explained by the fact that, under fractal conditions, the act of interaction of poly-orthotoluidine macromolecules with polyacrylic acid macromolecules occurs more successfully. Although under these conditions, poly-orthotoluidine macromolecules wander chaotically horizontally, but in the horizontal direction it is more convenient to occupy the interaction positions. For fractal structural formations, the pendulum hardness is 3,6 and the lattice notch adhesion is 5 in Table 1. This shows that in the process of interaction of polyanilines with polyacids under fractal conditions, a regular rearrangement of their intramolecular and supramolecular structures occurs. Regular distribution of the polyaniline chain along the macromolecular matrices of the polyacid. It should be especially noted that fractal-structural formations are a consequence of the horizontally directed interaction of a macromolecule-macromolecule. In the process of electrochemical synthesis, electric current and a matrix solution of polyacrylic acid show diffusion - dynamic effects and on physics - mechanical properties during the formation of fractal – structural interpolymer complexes. Formation of fractal-structural interpolymer complexes and composition depends on:

- on the diffusion-dynamic conditions of the matrix solution of the electrochemical process,
- on the length and structure (microstructure) of the polyaniline and polyacid chain, as well as on the applied electrical potential of the process.

4.CONCLUSION.

The fractal approach is useful in particular for understanding the formation of interpolymer complexes and polyanilines. Doping of polyaniline with proton-donor mineral acids (HCl, HF, H_2SO_4) is an inhomogeneous process, as a result of which only a small fraction of polymer "particles" becomes conductive. In the case of the interaction of polyaniline and polyacids, interpolymer complexes are formed, with which the entire polyaniline chain is completely doped with the polyacid, and becomes a highly conductive material. Based on the above, we can say the following conclusions:

- fractal structural condition of electrochemical synthesis is more acceptable for the preparation and study of interpolymer complexes of polyanilines with polyacids with better physical and mechanical properties,

- fractal structural interpolymer complexes can have electrical conductivity from $26,6 \cdot 10^4$ to $28,8 \cdot 10^4$ $om^{-1} \cdot cm^{-1}$ in comparison with samples synthesized by the chemical method,
- investigation of the process of formation of fractal-structural interpolymer complexes of polyanilines with polyacids can clarify some mechanisms of interaction of polyanilines with polyacids under conditions of electrochemical synthesis,
- in the aisles from 0,65 V, 0,75 V, 0,95 V, 1,2 V voltage of electric potential, different morphologies of fractal-structural interpolymer complexes of polyanilines with polyacids are formed.

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