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Synthesis of Monodisperse Latexes to Create Immunodiagnostic Drugs

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Abstract: The aim of this work was the synthesis of monodisperse latexes based on methyl methacrylate. To achieve this goal, methyl methacrylate was polymerized in an emulsifier-free static heterogeneous monomer-water system in the presence of hydroquinone and potassium persulfate. The size of the latex particles was determined by electron microscopy. Monodisperse latexes with a diameter of about 100 nm were synthesized as a result.

Key words: EP (Emulsion polymerization), latexes, methyl methacrylate, static system.

1. Introduction

The passive hemagglutination test in immunodiagnosis is usually used to diagnose diseases caused by bacteria and viruses. This reaction is also used to detect certain hormones and to identify a patient's hypersensitivity to drugs and hormones.

For the preparation of immunodiagnostic preparations, monodisperse latex particles are used, on the surface of which antigens (bacterial, viral, tissue) or antibodies are immobilized. Agglutination of latex particles occurs by adding appropriate sera or antigens to the latex [1-4]. The sorption properties of latex particles are determined by the chemical composition of their surface. Narrow distribution of dispersed polymer particles is a main requirement for immunological latexes.

The main method for the synthesis of latexes is EP (emulsion polymerization) [5-7]. The mechanisms of formation of latex particles during EP remain controversial; therefore, the synthesis of monodisperse latexes with a given particle diameter is carried out rather intuitively than according to pre-programmed recipes. EP is usually carried out in micellar emulsions. The surface of the latex particles is covered with emulsifier molecules during EP. This fact sharply limits the possibility of regulating the chemical structure of the surface of latex particles and expanding the range of immunological latexes.

The synthesis of immunodiagnostic latexes most often succeeds in emulsifier free heterogeneous static monomer-water systems [8-10]. The process of dispersion (nucleation of latex particles) in such a system occurs at the phase boundary [8, 10]. In the absence of an emulsifier, hydrophilic fragments of the monomer and initiator molecules stabilize the surface of latex particles. These circumstances make it possible to synthesize latexes of different purpose, changing the nature of the monomer and initiator. There remains, however, the need for a thorough purification of the monomer from the inhibitor, which is a laborious work.

To solve these problems we studied in this work the polymerization of MMA (methyl methacrylate) in a

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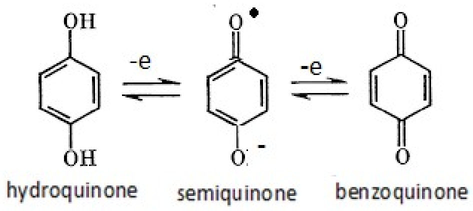
two-phase static system monomer-water using a redox system hydroquinone-potassium persulfate as an initiator.

2. Experiment and Discussion

The method of static polymerization is very simple [9]. The monomer cleaved from the inhibitor (hydroquinone) is carefully placed in thermostatically controlled test tubes on an aqueous solution of potassium persulfate. Polymerization is accompanied by turbidity of the aqueous phase.

The fact that elementary polymerization reactions occur at the interface between the monomer (with an inhibitor) and water suggests that hydroquinone dissolved in the monomer cannot inhibit polymerization and the process can be carried out without preliminary distillation of the monomer. It was also assumed that a redox reaction between hydroquinone and potassium persulfate would occur at the interface, leading to the formation of both sulfate ionic radicals and semiquinone radicals. The redox system hydroquinone-potassium persulfate, as a source of free radicals, has long been known and described in detail by Walling [11]. This reaction is considered bielectronic, however, polymerization can be initiated by both sulfate and semiquinone radical ions formed at the intermediate stage of hydroquinone oxidation:



$$S_2O_8^{-2} + e \Rightarrow SO_4^{2-} + SO_4^{-*}$$

persulfate ion sulfate ion sulfate ion radical

In Fig. 1, photos of the process of turbidity of the aqueous phase after the layering of MMA containing hydroquinone are illustrated. Turbidity begins at the interface (Fig. 1a) and rapidly spreads throughout the entire volume of the aqueous phase (Fig. 1b).

During polymerization, the latex dry residue is measured gravimetrically. The invariance of the dry residue indicates the degree of completion of polymerization. As a result of these experiments, a stable latex was obtained (Fig. 1c).

The stability of the synthesized latex is obviously associated with the presence of sulfate ions and quinone fragments, which were detected by an NMR1H spectrometer at δ 6.54 h ppm in poly-MMA latex (see Fig. 2).

Electron microscopic photos of synthesized poly-MMA latexes are shown in Fig. 3. It can be seen that the latex has a narrow particle size distribution; the particles' diameter is about 100 nm.

(a) (b) (c)

Fig. 1 Photos of the aqueous phase of the static system MMA (with hydroquinone): aqueous solution of potassium persulfate during the polymerization.

(a): at the initial stage of polymerization, (b): intermediate stage, (c): final latex.

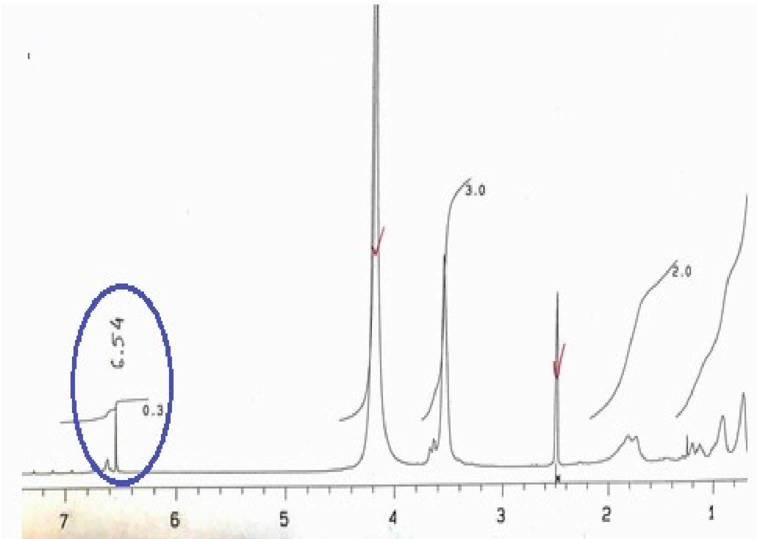


Fig. 2 NMR spectrum of the dry residue of polymethyl methacrylate latex.

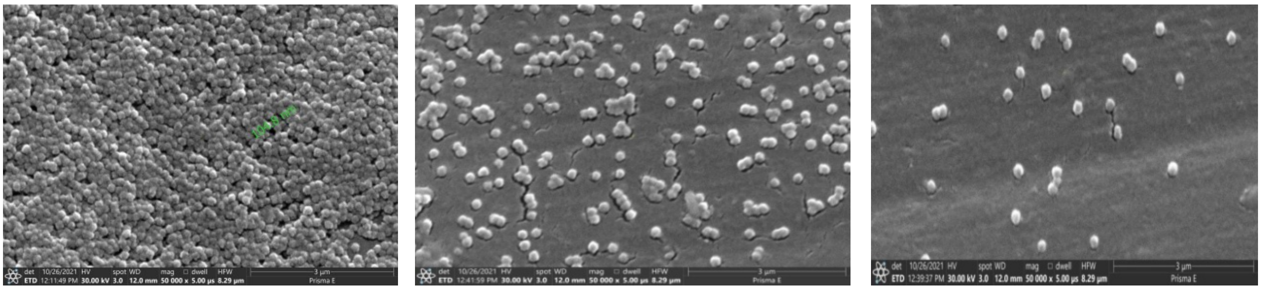


Fig. 3 Electron microscopic photos of polymethyl methacrylate latex obtained in the presence of hydroquinone.

3. Conclusion

The obtained results show that the polymerization of MMA in a heterogeneous static system monomer-aqueous solution of potassium persulfate proceeds successfully in the presence of hydroquinone and in the absence of an emulsifier. Stable monodisperse latexes are synthesized. The result obtained makes it possible to exclude the rather extensive and costly process of distillation of the monomer from the technological scheme of polymerization.

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