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Effect of the synthesis parameters on the antibacterial activity of the montmorillonite-zinc nanoparticles nanocomposite (MMT-NPZn)

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The additives industry for polymeric materials has been seeking innovations for application in active packaging and medical-hospital devices, especially with non-toxic antimicrobial additives. Antimicrobial nanocomposites have aroused significant scientific and technological interest for application in the active polymeric packaging for increase of the shelf life of food and for application in polymeric products with medical-hospital use. In this study, antibacterial nanocomposites composed of montmorillonite and zinc oxide nanoparticles (MMT-NPZn) were obtained and characterized. The synthesis of zinc oxide nanoparticles was conducted in reactive medias containing dispersed montmorillonite in aqueous medium with different concentrations, aiming to explore the characteristics of the basal spacings of the nanoclay in the nucleation process and to define the size of nanoparticles and the polar aggregates. Simultaneously, the homogeneous dispersion of the zinc oxide nanoparticles in montmorillonite particles favors the compatibilization of the nanocomposite with nonpolar polymeric materials. Hydrothermal method was employed for the syntheses of the zinc oxide nanoparticles. An aqueous solution of Zn(NO3)2.6H20 (1.0 M) was used as the zinc precursor and for neutralizing the reaction medium. The reaction medium consisted of different amounts of montmorillonite (Canadian montmorillonite) dispersed in a NaOH solution (0.5 M). For the organization and definition of the experiments, a full factorial experimental design type 24 was utilized to evaluate the effect of different parameters on the antimicrobial activity of the MMT-NPZn nanocomposite. The parameters studied included the temperature of the reaction medium (75.0°C – 85.0°C), flow rate of the zinc precursor solution (1.00 mL/min – 3.00 mL/min), agitation time (4h - 12h), and montmorillonite concentration (1.50g/80mL - 4.50g/80mL). The nanocomposite exhibited antibacterial activity against Staphylococcus aureus (Gram-Positive) and Escherichia coli (Gram-Negative) bacteria, with higher activity against Gram-positive bacteria. The temperature of the reaction medium, the flow rate of the zinc precursor solution and the stirring time were not significant in the antibacterial activity, but the decrease of the montmorillonite concentration in the reaction medium positively affected the antimicrobial properties of the nanocomposite (MMT-NPz). The nanocomposite obtained with the lowest concentration of montmorillonite showed the highest antibacterial activity. The nanocomposite MMT/NPZn with the highest antibacterial activity was characterized using Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), X-Ray Diffraction (XRD), Differential Scanning Calorimetry (DSC), Thermogravimetry Analysis (TGA), and Fourier-Transform Infrared Spectroscopy (FTIR). These are positive results for the study, indicating that the nanocomposite MMT-NPZn exhibits antimicrobial effects.