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In-situ preparation and characterization of pyrrole and tert-butyl 1-pyrrole-carboxylate on barium titanate/poly(acrylonitrile-co-methylacrylate) nanoparticles

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In this study, barium titanate $BaTiO_3$–poly(acrylonitrile-co-methylacrylate) [P(ANco-MA)]–polypyrrole (PPy) ($BaTiO_3$–[P(AN-co-MA)]–PPy) and $BaTiO_3$–[P(AN-co-MA)]–poly(tert-butyl 1-pyrrole-carboxylate) (TBPy) ($BaTiO_3$–[P(AN-co-MA)]–TBPy) nanocomposites were synthesized separately by in-situ emulsion polymerization in the presence of surfactant dopant dodecyl benzene sulfonic acid (DBSA). Particle size, yield, crystallinity, chemical structure and morphology were fully characterized and systematically studied.
Uniform particle size distributions of the nanocomposites were obtained. The size of the nanocomposites decreased with the addition of PPy and TBPy. The spectroscopic characterizations during the formation of ($BaTiO_3$–[P(AN-co-MA)]–PPy) and ($BaTiO_3$–[P(AN-co-MA)]–TBPy) nanocomposites were studied using Fourier transform infrared (FTIR–ATR) spectroscopy, ultraviolet–visible (Uv–Vis) spectrophotometry, and X-ray diffraction(XRD) spectroscopy. Analyses demonstrated that there is a strong interaction between the [P(AN-co-MA)]–PPy and $BaTiO_3$ and also [P(AN-co-MA)]–TBPy and the $BaTiO_3$. The morphological characterizations of the nanocomposites were examined by scanning electron microscopy and transmission electron microscopy. Efficient coverage was observed for $BaTiO_3$ nanoparticles with polymer shell.

1. Introduction

Conducting polymers have attracted considerable interest because they offer the possibility of introducing organic conductors in low dimensional, flexible and mechanically resistant systems with unique properties originating from their fully conjugated π-electron system. Polypyrrole derivatives are one of the most extensively studied materials due to their easy synthesis and good environmental stability [1,2].

Blends and composites of conductive polymers design with a variety of ferroelectric/magnetic particles and insulator polymers to improve electrical, magnetic and mechanical properties of polymeric materials [3–5]. The addition of inorganic fillers or conductive polymers to polymers introduces or modifies properties like electrical conductivity [6, 7], thermal stability, flammability [8] electrochemical, magnetic, optical and dielectric properties [2,9] and enhance stiffness and strength of the material [10] compared with the other inert polymers [11–23]. But this procedure often leads to poor processability and deteriorated mechanical properties for relative high filler contents [24,25]. The conductivity can be enhanced by adding a small amount of filler and by controlling its distribution and network formation in the matrix.

Among various fillers $BaTiO_3$ is a versatile electroceramics that finds widespread application and stands out due to high permittivity and a large propagation constant, leads to a high value of attenuation constant [5,6,26]. Ferroelectric properties and high dielectric constant [8,10,27, 28] make $BaTiO_3$ useful in an array of applications such as optics, optoelectronics, sensors, electromagnetic shielding applications [29] multilayer ceramic capacitors, gate dielectrics, waveguide modulators, IR detectors, and holographic memory [30]. At the room temperature, $BaTiO_3$ adopts a tetragonal perovskite type structure and among the many crystallographic forms, the tetragonal phase has the best dielectric properties [28].

Typically micron-sized perovskite-type ceramics (predominantly $BaTiO_3$) have been used as high-k-fillers. Nanosized $BaTiO_3$ ceramics give high permittivity due to the exploitation of the pronounced surface area to volume ratio [6]. However, the bandwidth of the barium titanate is too small for using as microwave absorption materials. If $BaTiO_3$ can be coated with insulator [24,25,31,32] and conductive polymers [26, 29,33–35] both the physiochemical properties and the conductivity performance are expected to be improved.

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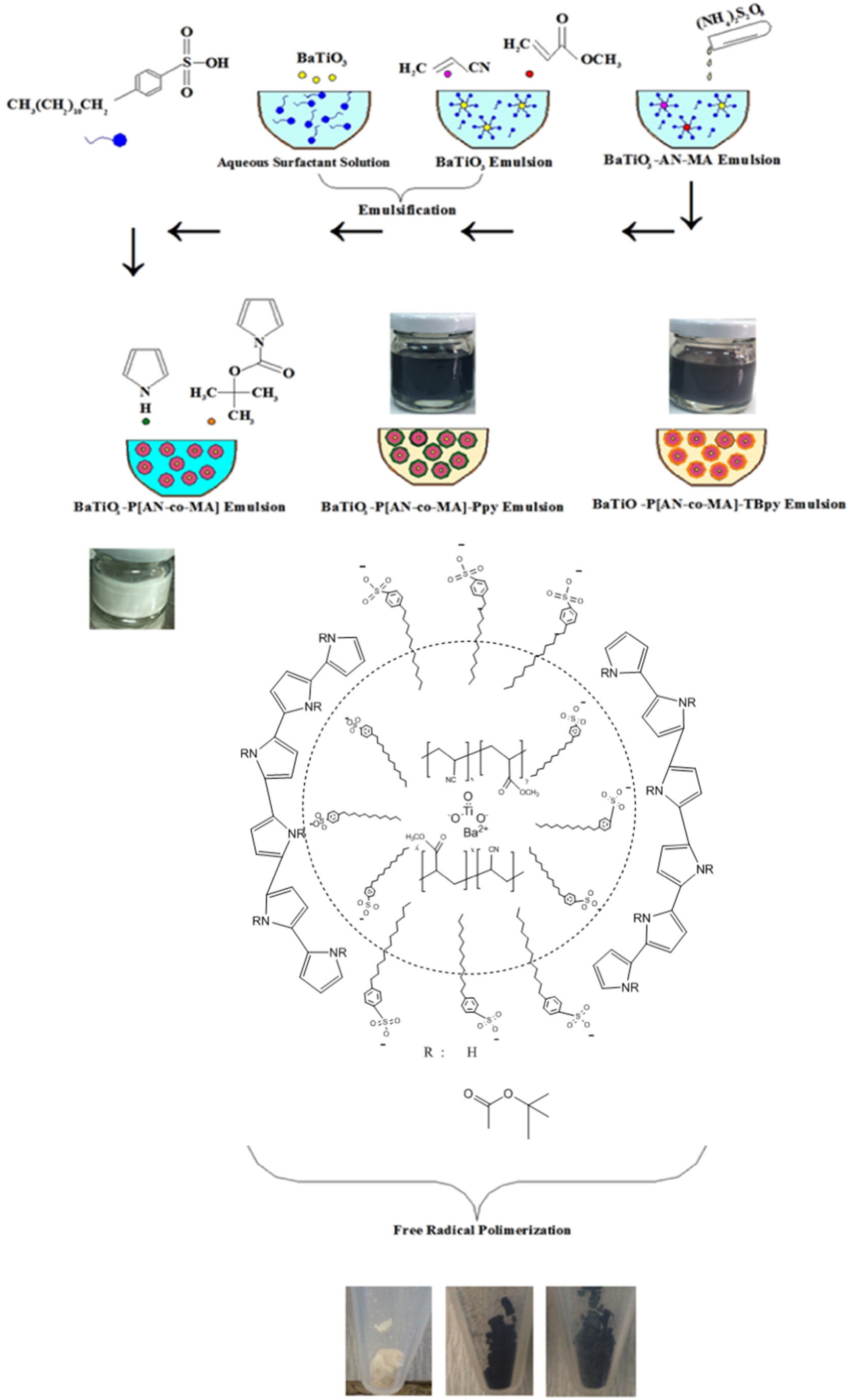

Fig. 1. Polymerization process of nanocomposites.