Enhanced degradation properties of polypropylene integrated with iron and cobalt stearates and its synthetic application

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ABSTRACT: Synthetic plastic leads to environmental contamination, and a promising solution to this problem is to use prooxidants as fillers within them to speed up the photooxidation and thermooxidation processes. This makes plastics more susceptible to biodegradation. In this study, the degradation properties of the widely used polymer polypropylene (PP) were improved by integration with cobalt stearate (CoSt2) and iron stearate (FeSt3) as prooxidants with accelerating weathering degradation. The metal stearates were blended with PP in the concentration range 0.1–0.9% w/w. The properties of the blends were studied by mechanical properties testing, thermogravimetric analysis, differential scanning calorimetry, and water absorption measurement. We performed the degradation properties and thermooxidative studies by conducting an accelerated weathering test on PP–metal salt blends. Fourier transform infrared spectroscopy and scanning electron microscopy analysis of the samples before and after the accelerated weathering test were performed to study the extent of degradation in PP-based metal salt blends. The results indicate that the tensile strength was inversely proportional to the concentration of metal stearates, and the samples showed an increased degree in polymer crystallinity (PPFe5 > PPCo5), and this led to the degradation of PP in less time. CoSt2 predominantly enhanced the degradation of PP in comparison to FeSt3. Food containers and pots were constructed with the tailored polymers of PP in the injection-molding machine. Thus, metal-stearate-integrated polymers have great industrial potential to generate value-added products. © 2017 Wiley Periodicals, Inc. J. Appl. Polym. Sci. 2017, 135, 46028.

KEYWORDS: blends; degradation; extrusion; mechanical properties; thermal properties

INTRODUCTION
Petroleum-based synthetic plastics have various uses in industry and in day-to-day life. They have become most desirable materials because of their properties, including its durability, high resistance, and low cost, and it can be easily manufactured and molded into various types of materials.1,2 These plastics have become a dangerous threat for living beings and ecosystem, highly affecting our earth because of its insubordinate nature, lack of degradability, and discarding issues.3,4 They consist of a long chain of artificial polymeric molecules.5 Recently, researchers have focused more on biopolymers, such as collagen, keratin, elastin, and myofibrillar protein,6 from different origins such as waste biomass7 and have used them to make plastics that can be used in food packaging8 and many other applications.

A statistical analysis performed by Barnes stated that about 10% of metropolitan waste products are only plastic-based9 and they do not easily degrade in the environment.5 A large amount of plastics have been disposed in landfills and water reservoirs, contaminating marine water, fresh water, and terrestrial and deserts habitats. Petro-based plastics are inert to microbial degradation, and this makes them accumulate for many years in the environment and makes them hazardous to living beings. Gregory9 stated that nearly 260 species of diverse insects, birds, reptiles, and mammals have shown discernable abnormalities in physical movement and eating habits, sterility, and death due to swallowing plastics or becoming interwoven in plastic wastes. In Australia and China, synthetic plastics bags were prohibited because of their hazardous effects on the ecosystem.10

The preparation of readily degradable plastics from petroleum resources and natural renewable resources and the blending of biodegradable polymers were studied.11 Polyolefins, such as polypropylene (PP) and polyethylene (PE), are resistant to hydrolysis, oxidation, and biodegradation.12 However, the addition of prooxidants to polyolefins cause them to degrade by a free-radical chain reaction and make them oxobiodegradable;1,11 this helps to promote abiotic (thermo or photo) and microbial degradation.13 Prooxidants are transition-metal-ion complexes added to polyolefins in stearates or other organic ligand complex forms. Prooxidants, such as Co2+, Mn2+, and Fe3+...