Can nanotechnology promote biodegradation of plastics?

It is well-known that plastic waste has become a major environmental problem. Would it not be wonderful if plastics could disappear as they were merely food waste? And even better, would it not be incredible if we can obtain these plastics from a simple corn cob? Now, this can be real with the new generation of plastics: bioplastics (Fig. 1.).

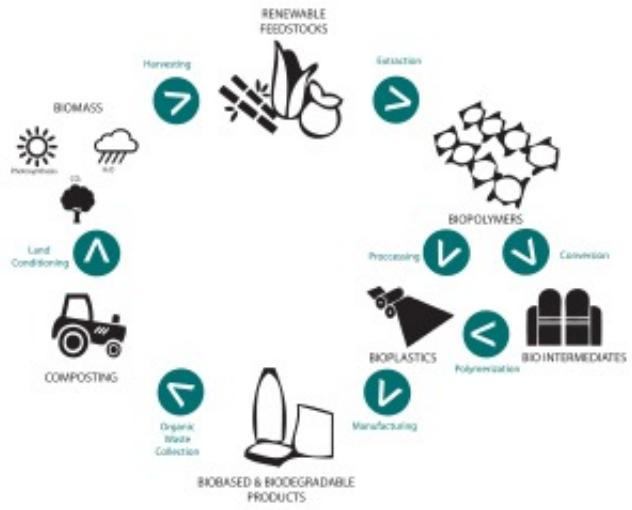

Fig. 1. Production, consumption, and disposal of biobased and biodegradable polymers via composting.

PLA, also known as poly (lactic acid), accomplishes both aspects: is biodegradable and is obtained from renewable resources; however, some of its properties such as mechanical resistance and barrier against gases must be improved to be employed satisfactorily in several applications. Nanotechnology, which uses particles of a size of one billionth of a meter, can achieve it. But, could these improvements alter the inherently biodegradable properties of this material? The answer is yes, but in a positive way.

Several new materials based on PLA incorporating nanoparticles were developed. Different tests were carried out in order to evaluate if these new materials could be recovered with the organic waste stream producing compost, which can be used as a soil fertilizer. If these plastics were “compostable” that would mean that they undergo degradation by biological processes during composting to yield carbon dioxide, water, inorganic compounds, and biomass in several months, and that they do not leave visually distinguishable or toxic residues that could affect plant growth. Thus the evaluation of compostability deals with aspects such as material characteristics, biodegradation, disintegration, and compost quality.

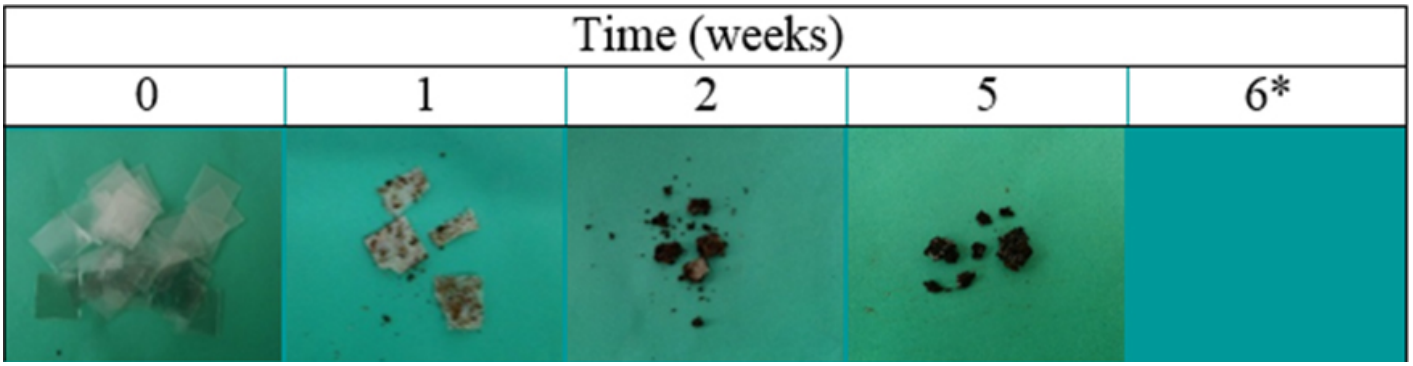

Fig. 2. Evolution of disintegration of PLA film under simulated composting conditions. *After 6 weeks sample completely disintegrated.

Results showed that disintegration of films of around 100 µm was complete after 6-7 weeks of incubation in composting environment (Fig. 2.). Moreover, no differences were observed in the evolution of the residue with respect to color, aspect, and odor in comparison with the control that did not contain any film. It was also observed that nanomaterials did not reduce the level of biodegradability of PLA. In fact, biodegradation was promoted in all the nanoreinforced samples after 130 days in composting, in several senses: (a) reducing the initial time to start the biodegradation, (b) increasing the biodegradation rate, and (c) producing a more biodegradable matrix. Finally, no adverse effects on the ability of compost to support plant growth were observed as a result of the incorporation of nanoparticles in the PLA matrix. This means that the number of germinated seeds and the plant biomass produced (measured as weight) did not differ from that of the plants sowed in the blank compost and that no visual defects were detected.

In conclusion, the incorporation of nanoparticles used as reinforcements in polymer matrices that are inherently biodegradable and possess a renewable origin could enhance their compostable character.

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Publication

Compostability assessment of nano-reinforced poly(lactic acid) films.
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