Infinitely Recyclable and Biodegradable Films for Improved Food Packaging

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Multilayer packaging is an extremely important and widely used technology; by combining many materials into a single film the final product can have properties that are unattainable by any single material. This has allowed major advancements in packaging; everything from sterile medical devices and medications to better food preservation for reduced food waste and improved food distribution to remote areas. These films are extremely lightweight, inexpensive, and can be tailored to have the precise properties required for a given application. This is important because each class of packaged food requires packaging with unique properties to maintain optimal freshness for the longest time possible. For example, snack foods with high fat contents (potato chips, nuts, etc.) require low oxygen and vapor permeability to avoid rancidity and a UV light barrier to avoid oxidation. Cereals are stored in films with only low moisture permeability. Despite these benefits, the use of different polymers (with different chemistries) all laminated into a single, inseparable film makes it impossible to recycle these materials, generating an enormous amount of plastic waste. Thus, it is critical to transition to sustainable multilayer films, which maintain the benefits of traditional single use packaging without producing plastic waste. **This can be achieved by transitioning from today's fossil fuel-based polyolefins to an ester-based paradigm that uses bio-derived materials to decarbonize the packaging industry.**

In the proposed effort, TDA Research, Inc. (TDA), the National Renewable Energy Laboratory (NREL), and Sulzer will work together to design ester-based films for multilayer packaging. We will optimize a compostable nanocomposite (made of surface-modified cellulose nanofibers (CNFs) in a compostable polymer matrix) to act as a strong food-contact layer with low water vapor permeability. The surface functionalization on the CNFs creates a cellulose additive that blends well with the polymer matrix to improve both the mechanical and barrier properties of the resulting composite. We will separately optimize a recyclable by design polymer to act as an oxygen barrier layer and as a printable outer layer (which is important so that food manufacturers to display product branding and information). The individual layers will be tested to evaluate their barrier properties and then will be layered together to create multilayer films. By using two ester-based materials, we will not need adhesives (or "tie layers") between the films, making a bio-derived, compostable and/or recyclable multilayer film. Technoeconomic analysis and lifecycle analysis (TEA/LCA) will be performed throughout the project to ensure we achieve cost parity (or reduction) compared to traditional multilayer packaging.

The result of this effort will be a multilayer film that is safe for food contact, has oxygen and vapor barrier properties comparable to traditional films, and is entirely compostable and/or recyclable.