PROGRESS AND PLANS OF NATIONAL NANOTECHNOLOGY INITIATIVE (NNI) AGENCIES

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U.S. Department of Agriculture (USDA)

Agriculture Research Service (ARS)

Summary

The USDA Agriculture Research Service has a small program that addresses research involving nanotechnology. For example, projects address the development of new commercial cotton products, including cotton-containing nonwoven materials; the use of biopolymers to develop sustainable technologies and bioproducts that will not negatively impact food reserves; the use of nonfood fibers and crop waste to create new bioproducts and to help improve efficiency in utilizing agricultural commodities; the development of advanced imaging technologies using nanoparticles to improve understanding of health and fertility in food animal reproduction systems, and to track bacterial pathogens in livestock hosts and foods combined with the development of pathogen mitigation strategies; and the development of novel food processing and packaging technologies to improve appearance, nutritional value, or product quality.

Key Technical Accomplishments

- The contamination of ready-to-eat meat products by foodborne pathogens is a concern for the meat industry. One of the potential solutions to prevent these pathogens is to wrap meats in films composed of natural biopolymers combined with nanotechnology. Edible antimicrobial composite films from microemulsions containing all-natural compounds using high-pressure homogenization technology were developed. Studies that mimicked industry food processing conditions revealed a 99.99 percent inactivation of pathogens after 35 days at 10°C.
- The silver nanoparticle-cotton system previously developed by ARS showed stable and durable antimicrobial properties in laundering tests. Simply copying the nanotechnology developed in other fields, i.e., buying nanoparticles, nanotubes, or nanocrystals and applying them onto textiles, has raised environmental, health, and performance durability issues. A great deal of originality is required to develop safe and durable nanoengineered cotton. The uniform dispersion of silver nanoparticles inside the fiber was not influenced by 50 cycles of laundering, and the laundered nanocomposite fibers retained 92% of the silver nanoparticles in concentration. More importantly, powerful antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* was maintained after laundering. This nanocomposite fiber will continuously deliver antibacterial activity wash after wash, making it a potential material for antibacterial washable wipes.
- A pioneering layer-by-layer self-assembly process would provide an excellent thermal protection material for medical, military, and large-scale emergency uses where a low-cost, short-term product is desired. Layer-by-layer (LbL) assembly is a simple method to incorporate various polymers, colloids, or nano-disperse clay particles onto cotton fabrics. These clay treatments impart novel physical and chemical properties to cotton, including moisture management, strength, and absorptivity. By treating

fabric with intumescent nano-coatings, composed of phosphorous-nitrogen rich polymers and prepared via LbL assembly, ARS found that the cotton fabric can be rendered anti-flammable. These materials are designed to be permanently attached to the cotton so as to not wash off during laundering. There is little doubt that if fire retardant treatments can be made safer and more durable, the market for cotton will increase greatly.

Plans and Priorities by Program Component Area (PCA)

PCA 3. Nanotechnology-Enabled Applications, Devices, and Systems

ARS will be pursuing R&D aimed at the following objectives:

- Utilizing nanotechnology in antimicrobial and odor reduction applications in livestock production, and in the extraction and characterization of nanoparticles and nanofibers from agricultural residues for agricultural air pollution mitigation.
- Utilizing conventional and novel processing technologies to produce and characterize nanofibers from biopolymers and investigate potential applications, and enable new commercial materials based on biopolymers and bio-based fillers.
- Enabling new commercial processes for the production of cotton-based products with enhanced flame retardant and moisture control properties; new commercial processes for manufacturing cotton-based body-contacting materials for use in biomedical, biosensor, and hygienic applications; and new commercial processes involving supercritical fluids, microwaves, ultrasound, or ionic liquids for the production of cotton-based products.
- Developing new *in vitro* and *ex vivo* approaches for cellular and tissue biophotonic imaging using nanoparticles, using nanoparticles for the tracking of pathogens to address bacterial abundance and persistence related to livestock well-being and production performance, and developing mitigation strategies.
- Enabling new commercial value-added bio-based materials and novel processing technologies to produce and characterize nanofibers from biopolymers and investigate potential applications, and new commercial materials based on biopolymers and biobased fillers.
- Developing nanobiosensors for pathogen detection in food animals and plants, and their derived products.