PROGRESS AND PLANS OF NATIONAL NANOTECHNOLOGY INITIATIVE (NNI) AGENCIES

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National Institute of Food and Agriculture (NIFA)

Summary

The NIFA nanotechnology portfolio will continue providing national leadership and investments in research, education, and extension activities through its extramural funding instruments. NIFA advances nanoscience and nanotechnology for addressing significant societal issues such as sustainable agricultural production, food and nutrition security, food safety and biosecurity, the bio-based economy, water and other natural resources, and environmental and ecological systems. The program also supports risk assessment and management, as well as public engagement and communication about nanotechnology and nanotechnology-enabled products.

Plans and Priorities by Program Component Area (PCA)

PCA 1. Nanotechnology Signature Initiatives (NSIs) and Grand Challenges

1d. Sensors NSI

NIFA has interests in nanotechnology-enabled sensors for food and agricultural applications such as food contaminant detection and intelligent precision agriculture. Low-cost sensor technologies and manufacturing that can be translated to commercial markets are particularly relevant to the food and agriculture sectors.

1e. Water NSI

NIFA's Agriculture and Food Research Initiative (AFRI) has supported multidisciplinary systems approaches that integrate new technologies and strategic management through a Challenge Area on Water for Food Production Systems. One large project in this challenge area has been exploring nanotechnology and smart decision analytics for irrigation water quality management. Its impact reaches multiple agricultural systems in different states. Its education component has been developing highly engaging programs for students and learners.

PCA 2. Foundational Research

NIFA continues to support fundamental research in nanoscale science and engineering for solving significant societal challenges facing agriculture and food systems. The scope of investigation ranges from discovery and characterization of novel nanoscale phenomena, processes, and properties that are relevant and

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important to agriculture and food; new platforms leading to novel applications; the exploitation of bio-nano interfaces; systems biology; additive manufacturing technology; and the broad social, ethical, economic, and legal implications of major emerging nanotechnology applications to society, agricultural markets, and consumer acceptance.

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

NIFA continues to emphasize its support for innovative and applied research on nanotechnology-enabled applications, devices, and systems for a wide range of agriculture and food priorities. The scope includes rapid detection and effective intervention technologies for ensuring food safety and biosecurity; effective treatments to improve animal health; novel value-added products; and utilization and protection of natural resources, the environment, and agricultural production ecosystems.

PCA 4. Research Infrastructure and Instrumentation

NIFA will continue supporting educational institutions for curriculum development and future workforce training. NIFA's AFRI Education and Workforce Development program supports various aspects of education for building institutional capacity and enhancing the pipeline for producing more STEM graduates to meet the projected shortfall in agriculture-related fields.

PCA 5. Environment, Health, and Safety

NIFA supports nanotechnology environmental, health, and safety research relevant to agricultural production and food applications. Risk assessments of the use of engineered nanoparticles in food and agricultural systems include characterization of hazards, exposure levels, and transport and fate of engineered nanoparticles or nanomaterials in crops, soils (and soil biota), livestock, and production environments. The program also supports research on transport and fate of engineered nanoparticles or nanomaterials associated with food production, processing, and interactions with microbiota in the human gastrointestinal tract.

Key Technical Accomplishments

The following are some selected examples of accomplishments arising from NIFA's nanotechnology research and development investments.

Printing and Powering Wearable Sensors and Electronic Tattoos

Using crumpled carbon nanotube forests, researchers funded in part by NIFA, the National Science Foundation, and the Department of Defense have created flexible supercapacitors to provide power to wearable and implantable electronic systems. The devices perform even when stretched hundreds of percent in various directions over thousands of cycles.[2]

Making Plant-Based Insulation Even Better than Petroleum-Based Foams

Researchers funded by NIFA have developed an environmentally friendly insulating material made from nanocrystals of cellulose. This is the first time that a plant-based material has surpassed the insulating

[2] https://onlinelibrary.wiley.com/doi/abs/10.1002/aenm.201900618

performance of polystyrene foam. The nanocrystals from wood pulp make up about 75 percent of the material, and the manufacturing process uses water instead of other harmful solvents. After use, the lightweight foam degrades well, and it does not produce a polluting ash when burned.[3]

Detecting and Degrading Contaminants in Water and the Environment

Researchers supported by NIFA have developed a sensor platform that is able to detect organophosphates, a type of insecticide, at levels forty times below the EPA recommended levels. The graphene sensor, made with an inkjet printer, is inexpensive and easy to use. This technique can enable monitoring of entire fields for pesticides and fertilizers, so farmers can limit application to what is needed. The sensor technology can also be adapted to detect pathogens and other compounds to promote food safety and monitor the environmental ecosystem.[4] Another team of researchers funded in part by NIFA has developed a process using nanoscale zerovalent iron to degrade common flame retardants that are associated with cancer and hormone disruption. The two-step process, developed by an international team of scientists, advances efforts to develop safe and effective methods to remediate groundwater and soil contaminated with these persistent pollutants.[5]

[3] https://doi.org/10.1016/j.carbpol.2019.04.059

[4] https://pubs.rsc.org/en/content/articlehtml/2019/nh/c8nh00377g

[5] https://pubs.acs.org/doi/10.1021/acs.est.8b06834