

# FOOD TECHNOLOGY

• Formulation • Analysis • Engineering



SOUTHWEST RESEARCH INSTITUTE®

## Southwest Research Institute®

Founded in 1947 as an independent, nonprofit research and development organization, Southwest Research Institute (SwRI) provides a significant research, engineering and testing resource for industry, business, and government. With nine technical divisions, SwRI uses a multidisciplinary, integrated approach to solving complex problems in science and applied technology. As part of a long-held tradition, patent rights arising from sponsored research at the Institute are often assigned to the client. SwRI generally retains the rights to Institute-funded advancements.

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# Food Technology: Formulation, Analysis, Engineering

Southwest Research Institute has been a leader in food-related science and engineering fields for more than 70 years. Support of the food processing and manufacturing industries is a core focus, and SwRI engineers have developed diverse solutions for food manufacturers and processing equipment suppliers using innovative techniques.

Institute staff members have developed and applied technologies to food-related applications and technologies, including:

## FORMULATION

- Micro/nanoencapsulation and particle engineering
- Nanomaterials
- Antimicrobial materials

## ANALYSIS

- Analytical chemistry
- Testing and failure analysis

## ENGINEERING

- Materials engineering for food applications
- Manufacturing systems

# MICRO/NANOENCAPSULATION

Using extensive expertise in diverse technical fields such as pharmaceuticals, food and nutrition, polymer and materials science, and process engineering, SwRI has been a leader in encapsulation research and development for more than 70 years. Institute encapsulation specialists solve product stability, release and application problems in a wide range of industries.

The Institute has conducted more than 1,000 encapsulation research programs for commercial and government clients, preparing capsules 10 nm to 10 mm with a wide range of materials. SwRI employs diverse bench and pilot-scale encapsulation methods to solve product performance requirements for its clients. Encapsulation methods are broadly categorized as either physical or chemical.

## Physical Methods

- Extrusion/co-extrusion
- Fluidized bed
- Pan coating
- Atomization
- Spinning disk
- Spray drying (electrostatic, inert, solvent)
- Spray chilling/congealing

## Chemical Methods

- Solvent evaporation
- Coacervation/phase separation
- Interfacial/*in-situ* polymerization
- Nanoencapsulation
- Micelles
- Nanoemulsions
- Liposomes
- Sol-gel

## Facilities

- ISO 9001:2015
- Good Manufacturing Practices (cGMP)
- Lab- and pilot-scale encapsulation

## Encapsulation Formulation & Release

- Shell materials: GRAS, kosher
- Custom release rates and/or profiles
- Release mechanism examples
  - mechanical rupture
  - thermal release
  - permeation
  - shell dissolution
  - pH trigger
  - biodegradation

## Capsule Analysis

- Spectroscopy/chromatography
- Payload
- Content uniformity and stability
- Release profiles
- Ingredient activity
- Optical/electron microscopy
- Particle size analysis (3 nm to 3 mm)
- Zeta-potential analysis
- Surface analysis (AFM, EDX)
- Thermal analysis (DSC, TGA)

## Food Application Examples

- Probiotics, bioactives
- Functional foods
- Taste masking
- Color masking
- Flavor stabilization
- Oxidation stability
- Shelf life improvement
- Formulation stability
- Liquid-to-solid conversion



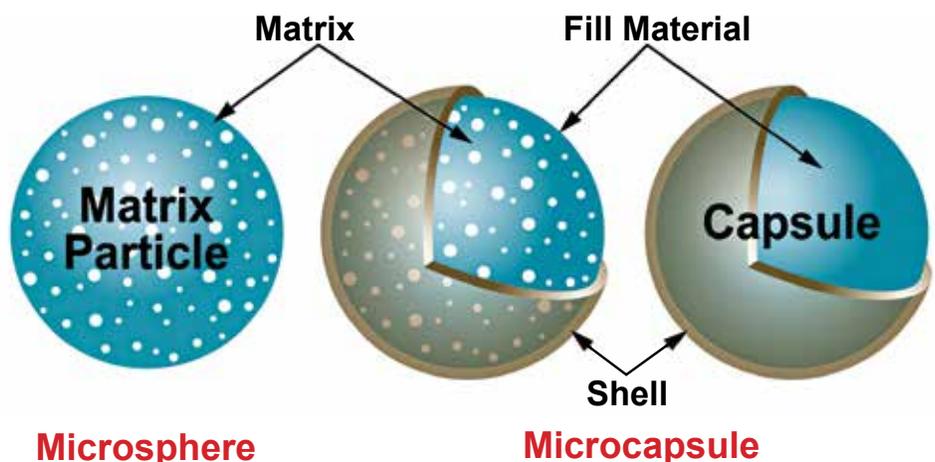
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SwRI scientists develop encapsulated products for agricultural applications such as sustained release of pesticides and fertilizers, stabilization, and increased bioavailability of animal feed nutrients and seed protection.



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The Institute employs a number of chemical methods to develop highly stable microcapsules as small as 100 nm.



Particle size and morphology can be tailored to achieve the desired product performance.

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# NANOTECHNOLOGY

Nanotechnology is a diverse field, united only by the factor of scale. At SwRI, multidisciplinary teams of scientists and engineers bring together advanced technologies on the smallest of scales to provide solutions to large and small problems.

Institute scientists use advanced engineering and fundamental chemistry, physics and material sciences, along with innovative computational capabilities, to solve specific problems in molecular modeling, nanomanipulation and fabrication, molecular templating and processing.

SwRI has well-equipped laboratories, facilities and equipment, including scanning electron microscopes, a focused ion beam mill and silicon wafer-handling equipment. Drawing upon expertise in numerous fields, Institute engineers offer services in design engineering, training and virtual data manipulation, fabrication and characterization.

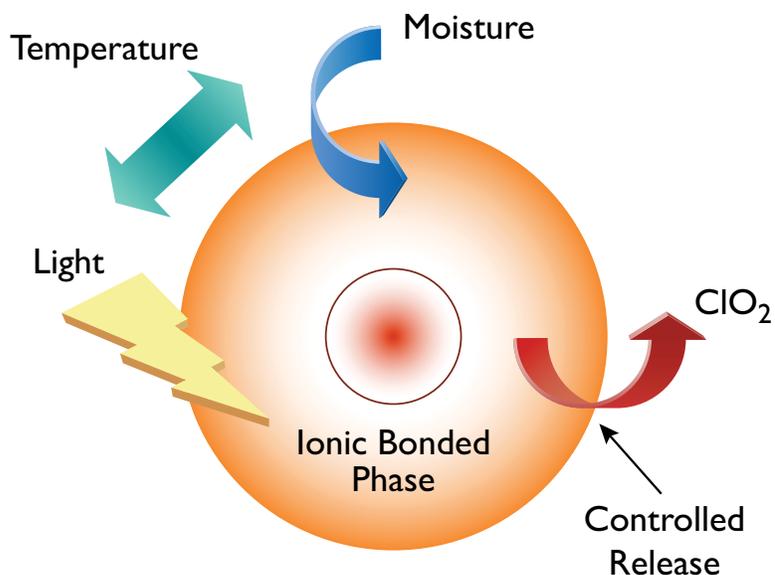
The Institute provides solutions in nanosciences including:

- Nanocomposites
- Nanoencapsulation
- Nanoengineered materials
- Nanofabrication
- Nanosensors



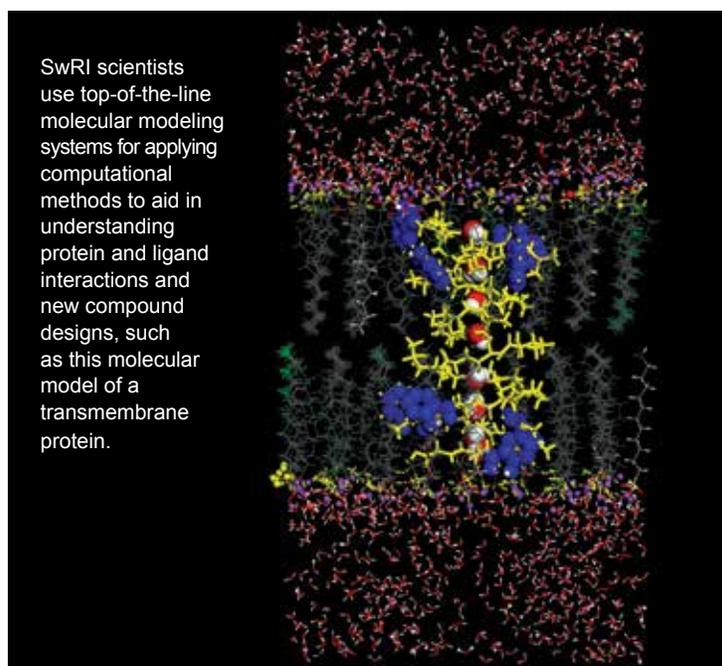
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SwRI scientists develop microcapsules containing nanoplatelet fillers at the shell wall to provide oxygen- and water-barrier properties. These fillers enable development of next-generation nutritional and functional food products such as fish oil.



Exposure to light instantly activates ClO<sub>2</sub> production of an SwRI-licensed technology, eliminating microbes and pathogens and neutralizing undesirable odors. By removing or decreasing light, the release of ClO<sub>2</sub> may be reduced or stopped.

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SwRI scientists use top-of-the-line molecular modeling systems for applying computational methods to aid in understanding protein and ligand interactions and new compound designs, such as this molecular model of a transmembrane protein.

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# ANALYTICAL SERVICES

Using state-of-the-art laboratories, Institute scientists have a wide range of experience in performing chemical analysis for nutritional labeling, pesticide residues, metals determination, and the detection of various chemical contaminants. The laboratories provide analytical support for research and development, production, and quality assurance activities.

Institute scientists develop new methodologies as needs arise. The laboratories have provided quick implementation of methodologies for detection of trace levels of NDMA, acrylamide, glyphosate, and furans, among many other emerging issues, such as the leaching of potentially harmful chemicals from food packaging materials.

SwRI specializes in providing unconventional problem solving. Institute scientists utilize the power of non-targeted analysis to determine the chemical makeup of foods, to check for authenticity of foods, perform quality checks, and potential contaminant analyses. The employment of machine learning via the SwRI-developed artificial intelligence software, Floodlight™, provides a high level of efficiency to analyze the large of amount of data produced in non-targeted analyses.

A wide range of instrumentation is available to complete these analytical projects, including GCxGC-TOFMS, GCxGC-HRTMS, LC-QTOFMS, LC/MS/MS, GC/MS/MS, HRGC/MS, GC/MS, GC, LC, ICP, ICP-MS, IC, and all wet chemistry and gravimetric equipment.

## Laboratory Accreditations

- ISO 17025:2017
- ISO 9001:2015
- NELAP – National Environmental Laboratory Accreditation Program
- Food and Drug Administration (FDA) registration
- Drug Enforcement Administration (DEA) schedules I-V (Researcher I-V; Manufacturer II-V)



SwRI analysts prepare food samples for extraction in one of the Institute's state-of-the-art laboratories.

SwRI scientists conduct a variety of nutritional analyses including water and fat-soluble vitamins, amino acids, fatty acids, sugars and carbohydrates, proteins, and cholesterol determinations.

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Sample extracts on a gas chromatograph/mass spectrometer instrument are ready to be analyzed.



SwRI scientists have extensive experience in the determination of contaminants and unknowns. At right, produce is in the pesticide analysis process.

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# MANUFACTURING SYSTEMS

SwRI technical staff provides professional engineering services in the development and transfer of technology solutions for production operations. The Institute develops and deploys diverse solutions for food manufacturers, distributors, and processing equipment suppliers. Typically, projects are instigated by new product or process development, cost reduction, improved quality of existing products, higher capacity processing systems, less human interaction with the product, reduction in environmental footprint, and better equipment reliability.

Core manufacturing systems capabilities include:

- Turnkey production system development
- Operations improvement
- Diverse portfolio of subject matter experts and testing equipment
- Robotics and automation solutions
- Inspection systems
- Human-robot collaboration
- Novel process development
- Independent verification and validation
- System performance assessments

Production system development activities range from optimizing an existing process for a revised formulation to new equipment development and process specification. SwRI designs, builds and validates a broad range of equipment and transfers the resulting technology to the end-user or a vendor of choice.

SwRI provides a suite of services in lean manufacturing, six-sigma, process modeling and quality systems. These operations improvement services range from single-day training or focused events to full plant value-engineering activities.

Automation solutions range from robotic applications that include material handling, palletizing and dispensing to developing custom automation equipment using a rigorous design methodology that is focused on meeting client requirements. Software expertise, especially with path planning, enables automated solutions for uniform and non-uniform raw and finished material, such as protein and produce, processing and sorting.

Typical approaches in nondestructive inspection of raw materials, finished products and packaging include machine vision, spectral analysis, X-ray, laser sensing, terahertz sensing, IR sensing, and 3D scanning.



Our automation experts have experience in industrial food manufacturing including food extrusion and mixing.



We create solutions for picking, placing, and moving items of all shapes and sizes including when a mix within the same line exists.



SwRI supports clients wishing to automate their raw food sorting for size, shape, and even color.



Custom mobile robotic solutions assist in spaces where robotic access was previously limited.

# MATERIALS ENGINEERING & FAILURE ANALYSIS

## Materials Engineering

Institute specialists in materials processing work closely with testing and characterization experts to rapidly develop new materials that can be safely used in direct contact with food. SwRI has more than 5,000 square feet of state-of-the-art facilities and more than 10 vacuum chambers dedicated to surface modification and coatings of advanced materials with capabilities that include:

- Deposition techniques to enhance surface properties
- Plasma enhanced magnetron sputtering (PEMS)
- Plasma immersion ion deposition (PIID)
- Ion beam assisted deposition (IBAD)
- Wet chemistry based technologies
- Materials characterization including atomic force microscopy (AFM), fiber optic probes, Raman spectrometers and infrared spectrometers
- Unique materials such as diamond-like carbon (DLC), nanocomposite TiSiCN, TiN, CrN and carbon nanotubes (CNTs)

Projects range from small-batch, single-day processing to long-term research and development including friction and wear reduction in metal and ceramic components, biocompatible and catalytic coatings for polymeric materials, and treatments for corrosion and oxidation resistance.

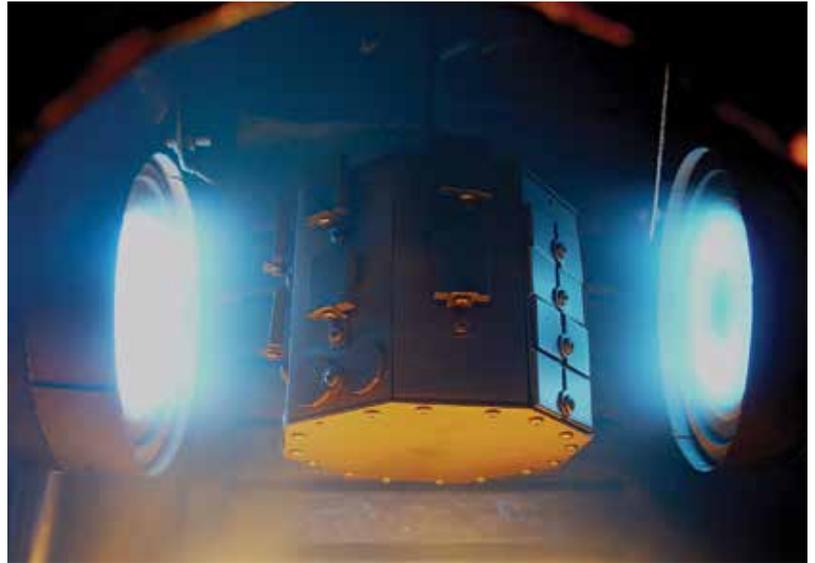
## Evaluation and Failure Analysis

Using systematic failure analysis, SwRI's materials science and failure analysis teams often can isolate causes of catastrophic and minor failures. SwRI engineers and laboratory technicians have extensive experience in identifying failure mechanisms including:

- High- and low-cycle fatigue
- Stress corrosion cracking
- High-temperature degradation
- Brittle failure
- Fretting and wear
- Weld defects
- Various forms of corrosion attack

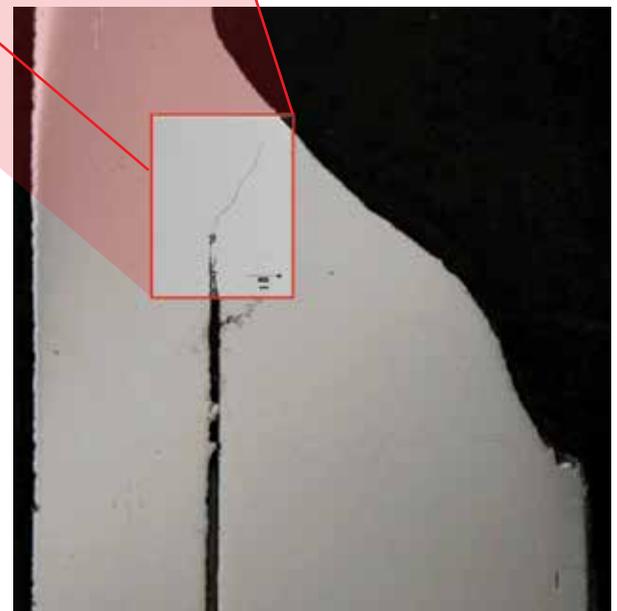
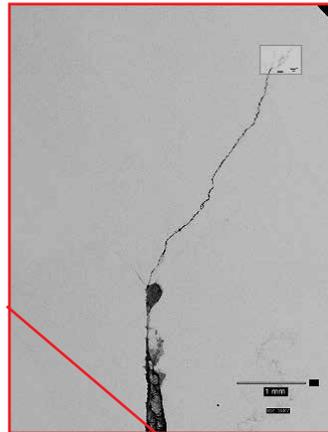
When failure investigations require in-depth studies, SwRI applies:

- Corrosion evaluation
- Nondestructive evaluation
- Finite element analysis
- Damage tolerance assessment
- Life extension forecasts
- Mechanical testing
- Metrology lab
- Surface engineering
- In-service condition assessment
- Maintenance optimization
- Design/redesign services



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Using PEMS technology SwRI deposits super hard, very tough and extremely erosion-resistant nanocomposite coatings on food processing equipment and other components to improve wear resistance by orders of magnitude over the base substrate.



The figures show highlights of a failure investigation that started with an active leak in a socket weld that developed after 25 years of service. Various optical and scanning electron microscope images, taken in the course of the investigation, confirmed that this leak resulted from a slow-growing stress corrosion crack that initiated at a weld defect.

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Southwest Research Institute, an independent, nonprofit applied engineering and physical sciences research and development organization with nine technical divisions, uses multidisciplinary approaches to problem solving. The Institute occupies more than 1,500 acres in San Antonio, Texas, and provides more than 2.3 million square feet of laboratories, test facilities, workshops and offices for approximately 3,000 employees who perform contract work for industry and government clients.

Benefiting government, industry and  
the public through innovative  
science and technology



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