Conductive Polymers

Federal Manufacturing & Technologies

J. W. Bohnert

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Final Report/CRADA Project Accomplishments Summary

CRADA Number 01KCP1094

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United States Department of Energy

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Honeywell

Federal Manufacturing
& Technologies

P. O. Box 419159

Kansas City, Missouri

64141-6159

A prime contractor with the United States
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Honeywell

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Date: Oct 11, 2002 Revision: 0

A. Parties

The project is a relationship between

Honeywell FM&T

1000 E 95th Street

PO Box 419159

Kansas City, MO 64141-6159

and

GRACE Photonics Inc.

10 North 5th Street

Charleston, IL, 61920

3. Background

Polymers that exhibit electrical conductivity are of great interest to researchers in fields of photovoltaics,

electroluminescent devices such as light-emitting diodes (LED) and high-energy density batteries. These new polymers offer cost savings, weight reduction, ease of processing, and inherent rugged design compared to conventional semiconductor materials. The photovoltaic industry has grown more than 30% during the past three years. Lightweight, flexible solar modules are being used by the U.S. Army and Marine Corps for field power units. LEDs historically used for indicator lights are now being investigated for general lighting to replace fluorescent and incandescent lights. These so-called solid-state lights are becoming more prevalent across the country since they produce efficient lighting with little heat generation. Conductive polymers are being sought for battery development as well. Considerable weight savings over conventional cathode materials used in secondary storage batteries make portable devices easier to carry and electric cars more efficient and nimble. Secondary battery sales represent an \$8 billion industry annually.

TRACE Photonics Inc. is a small research and development company located in east central Illinois, involved in a variety of high-technology activities. They specialize in polymer synthesis and formulation, nuclear batteries for microelectronics, and photoluminescent films. They have expertise in hydrogen and tritium work and keen insight into high-energy density materials. TRACE Photonics Inc. received the 2002 Army Small Business Innovative Research (SBIR) Phase II Quality Award.

Aldrich Chemical Company has selected TRACE Photonics Inc to supply research quantities of conductive polymers for catalog sales based on their ability to produce high-quality product.

Honeywell Federal Manufacturing & Technologies (FM&T), a prime contractor for the National Nuclear Security Administration, employs 3000 associates at facilities in Kansas City, MO; Albuquerque, and Los Alamos, NM. The Kansas City Plant manufactures a wide variety of nonnuclear mechanical, electronic, and engineered material components for national defense systems. Over 40 technically demanding product families are supported, including microelectronics, plastics, and polymers.

FM&T has extensive experience in the characterization of polymers. Analytical testing and analysis capability at FM&T has supported 50 years of plastic processing of high-reliability components. This expertise, combined with TRACE's experience in the areas of synthesis and formulation, complements this project.

2. Description

The purpose of the project was to synthesize and characterize conductive polymers. TRACE Photonics Inc. has researched critical issues which affect conductivity.

Much of their work has focused on production of substituted poly(phenylenevinylene) compounds. These compounds exhibit greater solubility over the parent polyphenylenevinylene, making them easier to process. Alkoxy substituted groups evaluated during this study included: methoxy, propoxy, and heptyloxy. Synthesis routes for production of alkoxy-substituted poly phenylenevinylene were developed. Considerable emphasis was placed on final product yield and purity.

Poly(p-phenylenevinylene)

Polymeric precursors and polymers were synthesized and delivered to FM&T for evaluation. They included: poly(p-phenylenevinylene) and substituted poly(p-phenylenevinylene) precursors, poly(2-methoxy-5-heptyloxy) p-phenylenevinylene, poly(1-propoxy-4-cyclohexyl-methyloxy) p-phenylene vinylene and substituted copolymers. Substituted poly(p-phenylenevinylene) copolymers included equal molar and 3:1 mole ratio of poly(2-methoxy-5-heptyloxy) and (1-propoxy-4-cyclohexylmethyloxy)-p-phenylenevinylene. Composition characterization of each lot was completed using direct probe mass spectrometry. Example spectra for these lots are attached. They compare well with the TRACE Photonics Inc. predicted structure.

TRACE Photonics Inc. has successfully demonstrated their ability to modify complex polymers. The addition of various alkoxy groups to parent PPV broadens the manufacturing possibilities for future photovoltaic and luminescent devices.

D. Expected Economic Impact

Increased knowledge of conductive polymer synthesis gives TRACE Photonics Inc. a competitive advantage as a supplier in this emerging market. These new materials offer manufacturers an alternative processing method not possible with insoluble PPV films. Adaptation of this technology to large-scale photovoltaic production would greatly impact the industry by providing low-cost semiconductor materials. Savings from lower raw cost materials can be passed on to the consumer.

E. Benefits to DOE

Experience in conductive organic materials was gained. Expertise in synthesis and reformulation of conductive polymers with improved properties was also realized. Conductive polymers with improved solubility were developed by addition of alkoxy groups. This experience is useful for development of lightweight, rechargeable batteries.

F. Industry Area

Photovoltaic, electronic, and high-energy density batteries

G. Project Status

Completed as scheduled

I. Point of Contact for Project Information

Ken Bauer

JS Department of Energy

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I. Company Size and Point of Contact

Kenneth E. Bower, Ph.D.

TRACE Photonics Inc.

217.348.6713 phone, 217.348.7964 fax

Number of employees: 3

J. Project Examples

PV precursor, conductive polymeric films, and conductive polymeric solutions

K. Technology Commercialization

Unknown to date

L. Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by Honeywell FM&T and agree that the information about our CRADA may be released for external distribution.

Original signed by 11/4/2002

Name: Kenneth E. Bower Date

Organization: TRACE Photonics
Inc.

Title: President

Example Spectra

Poly (2-methoxy 5-heptyloxy) -p-phenylene vinylene

poly(2-propoxy-5-cyclohexyl methyloxy) p-phenylenevinylene