INDUSTRIAL MATERIALS FOR THE FUTURE

Project Fact Sheet

LOW-COST SYNTHESIS AND CONSOLIDATION OF TITANIUM CARBIDE

BENEFITS

- Enhances mechanical properties and wear resistance of TiC composites by reducing particle size
- Significantly reduces production energy by shortening processing time through use of ambient-temperature processing
- Reduces high cost of synthesized TiC powder, making it cost effective for use in creating cutting tools
- Eliminates CO gas by-product of conventional TiC synthesis

APPLICATIONS

Low-cost processing of TiC would allow its use in the cutting-tool industry and other high-temperature, wear-resistant applications. Ultra fine TiC powder could also be used in the chemical industry as a catalyst, and in the transportation industry as an abrasion- and corrosion-resistant, high-temperature coating.

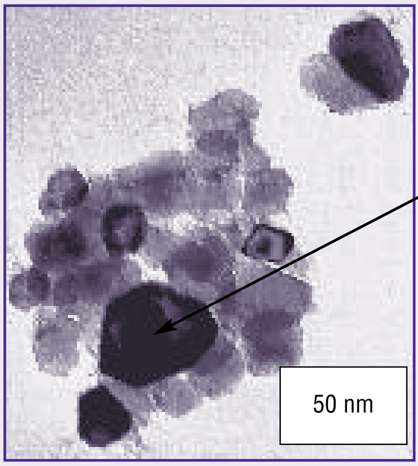
NEW MECHANOCHEMICAL PROCESS DELIVERS ULTRA FINE TITANIUM-CARBIDE POWDER FOR USE IN THE FABRICATION OF CUTTING TOOLS

Titanium carbide (TiC) is a model structural material due to its hardness, high-temperature stability, and low density. However, the widespread use of TiC in cutting tools and other applications has been limited because the production of TiC has not been cost effective and the fracture strength of the material has resulted in poor fracture toughness.

The insufficient fracture toughness of conventionally produced TiC is characteristic of the synthesis process used, which involves reduction of titanium dioxide by carbon black at high temperatures. These high process temperatures, in addition to increasing costs, also result in the formation of the large carbide particles that can cause failure of TiC-based cemented carbides. However, the use of smaller carbide particles for the production of fine-grained composites is prohibitively expensive.

A new technology, low-cost synthesis and consolidation of TiC, is being developed as a cost-effective mechanochemical processing method that yields an ultra fine titanium-carbide powder. In this process, mechanical milling fosters an ambient-temperature reaction to produce extremely fine TiC powder, which is then combined with low-cost, iron-based alloy powders. This mixture is then consolidated to produce a titanium-carbide product that can then be used in cutting tools.

MICROGRAPH OF NANOCRYSTALLINE TIC PRODUCT



Multifaceted TiC crystals produced through a new mechanochemical process should prove cost effective for use in the fabrication of cutting tools.

Project Description

Goal: Demonstrate a cost-effective process for the synthesis of ultra fine TiC powder through an ambient-temperature mechanical process and consolidate this powder with iron-based alloy powders to form fine-grained metal matrix composites.

The low-cost synthesis and consolidation of the TiC process synthesizes TiC from two low-cost precursors. Reactants are mechanically milled to induce the reaction in a short processing time. The reaction products are TiC and free carbon in a $CaCl_2$ matrix. The by-product salt, $CaCl_2$, is leached out, leaving nanocrystalline TiC powder.

Iron-based alloy powders are combined with the ultra fine TiC powder to produce a nanoscale mixture, which is consolidated to form a fine-grained metal matrix composite. Densification may occur by cold compaction, sintering, hot pressing or other powder metallurgy methods generally used.

The University of Idaho is developing this new technology with help from a grant funded by the Inventions and Innovation Program in the Department of Energy's Office of Industrial Technologies.

Progress and Milestones

- Determine parameters for control of reaction rate and particle size.
- Produce sufficient quantities of TiC, as well as TiC and metal powder mixture, for consolidation experiments.
- Conduct consolidation experiments with press and sinter techniques.
- Characterize nanocrystalline TiC powders and metal matrix consolidates.

Economics and Commercial Potential

Low-cost synthesis and consolidation of TiC offers tremendous potential for energy and cost savings in production of a material with highly desirable characteristics for application in cutting tools. Currently, large-scale commercial use of TiC is not widely used due to the lack of a manufacturing process to produce ultra fine material at an affordable cost. Titanium-carbide powder currently costs as much as $100 per kg for 2mm size particles, with cost increasing for smaller, more desirable particle sizes. This new low-cost synthesis process will furnish nanocrystalline carbide powder at lower cost.

The reduced production cost results in part from energy savings. Commercial-grade TiC is currently created by heating TiO_2 with carbon to temperatures in the range of 1200 to 2000°C, while the new synthesis and consolidation process takes place at ambient temperature. Also, while current means of TiC production use expensive processes or materials, the proposed mechanochemical process is easily scalable and does not require expensive equipment. Although current processes for TiC production generate the by-product gas CO, the new process forms only salts from which calcium and magnesium can be recovered.

Industrial Materials for the Future

The Industrial Materials for the Future Program focuses on the development and commercialization of new or improved materials that enhance productivity, product quality, and energy efficiency in the major process industries. These materials resist high-temperature fatigue, corrosion, and wear. Research focuses on metallic and intermetallic alloys, structural polymers and membrane materials, and materials processing methods.

The OIT Industrial Materials Leader: Charles A. Sorrell (202) 586-1514.

The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and conduct early development. Ideas that have significant energy savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

Project Partners

Inventions and Innovation Program
Washington, DC

University of Idaho
Moscow, ID

For Project Information, Contact:

E.G. Baburaj, Ph.D. or
F.H. Froes, Ph.D.
Institute for Materials and Advanced Processes (IMAP)
University of Idaho
Moscow, ID 83844-3026
Phone: (208) 885-7989
Fax: (208) 885-4009
imap@uidaho.edu
www.mines.uidaho.edu/imap

For Program Information Contact:

Lisa Barnett
Program Manager
Inventions and Innovation Program
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585-0121
Phone: (202) 586-2212
Fax: (202) 586-7114
lisa.barnett@ee.doe.gov

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Office of Industrial Technologies
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121

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