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**ASSESSMENT OF RESEARCH NEEDS FOR ADVANCED
HETEROGENEOUS CATALYSTS FOR ENERGY
APPLICATIONS. FINAL REPORT: VOLUME 2,
TOPIC REPORTS**

**CONSULTEC SCIENTIFIC, INC.
KNOXVILLE, TN**

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FINAL REPORT

**ASSESSMENT OF RESEARCH NEEDS
FOR ADVANCED HETEROGENEOUS CATALYSTS
FOR ENERGY APPLICATIONS**

Prepared for:

**U.S. Department of Energy
Office of Energy Research
Office of Program Analysis**

By:

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ABSTRACT

This report assesses the direction, technical content, and priority of research needs judged to provide the best chance of yielding new and improved heterogeneous catalysts for energy related applications over a period of 5-20 years. It addresses issues of energy conservation, alternate fuels and feedstocks, and the economics and applications that could alleviate pollution from energy processes.

Recommended goals are defined in three major, closely-linked research thrusts:

- I. **CATALYTIC SCIENCE** — Establish a scientific knowledge of essential catalyst structure/performance relationships and work toward developing the ability to predict the catalytic capabilities of novel materials.
- II. **ENVIRONMENTAL PROTECTION BY CATALYSIS** — Prevent pollution by developing economical processes that are free of pollutant formation. Diminish pollution by achieving higher selectivity in fuels and chemicals manufacture and by new and improved catalytic processes for the removal of pollutants.
- III. **INDUSTRIAL CATALYTIC APPLICATIONS** — Develop energy-saving, environmentally benign processes for manufacture of liquid fuels and commodity chemicals based on domestic natural gas, biomass, and coal. Emphasize research on synthesis gas ($\text{CO} + \text{H}_2$) production and conversion, oxidation catalysis, new methods of hydrogen production, and the synthesis of novel materials for catalytic applications.

This study was conducted by an eleven-member panel of experts from industry and academia, including one each from Japan and Europe. Discussions were held with a wide variety of authorities, supplementing an intensive review of technical literature. Panel conclusions were assisted by critical peer reviews.

There is a high level of confidence that the research proposed can provide catalytic technology which will achieve major economic and environmental improvements in energy applications.

Volume I provides a comprehensive Executive Summary, including Research Recommendations. Volume II first presents an in-depth overview of the role of catalysis in future energy technology in chapter 1. Then current catalytic research is critically reviewed and research recommended in eight topic chapters: 2. Catalyst Preparation: Design and Synthesis; 3. Catalyst Characterization: Structure/Function; 4. Catalyst Performance Testing; 5. Reaction Kinetics/Reactor Design; 6. Catalysis for Industrial Chemicals; 7. Catalysis for Electrical Applications; 8. Catalysis for Control of Exhaust Emissions; and, 9. Catalysts for Liquid Transportation Fuels from Petroleum, Coal, Residual Oil, and Biomass.

EXPERT PANEL

This report has been prepared by a panel of experts who have evaluated the research needs for advanced heterogeneous catalysis for energy applications. The project has been conducted under a grant to Consultec Scientific, Inc., Knoxville, TN from the U.S. Department of Energy, Office of Energy Research. Dr. G. Alexander Mills served as the Principal Investigator. The following distinguished scientists served as members of the panel:

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ACKNOWLEDGMENTS

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The panelists are greatly indebted to literally hundreds of individuals and their companies and organizations for helpful discussions, technical suggestions, technical input, and advice during the preparation of this report.

Special thanks are expressed to the peer reviewers of the report who are listed below. Their comments and criticisms were invaluable in improving the quality and completeness of this report.

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