CHEMICAL RESEARCH PROJECTS OFFICE:
FUNCTIONS, ACCOMPLISHMENTS, PROGRAMS

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Ames Research Center
Moffett Field, Calif. 94035

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational Chart</td>
<td>2</td>
</tr>
<tr>
<td>Purpose and Scope</td>
<td>3</td>
</tr>
<tr>
<td>Accomplishments</td>
<td>3-5</td>
</tr>
<tr>
<td>Group Functions:</td>
<td></td>
</tr>
<tr>
<td>a. Engineering Evaluation and Test Group</td>
<td>5</td>
</tr>
<tr>
<td>b. Polymeric Materials Development Group</td>
<td>6</td>
</tr>
<tr>
<td>c. Chemical Kinetics and Engineering Group</td>
<td>6</td>
</tr>
<tr>
<td>d. Sealant Project Team</td>
<td>6</td>
</tr>
<tr>
<td>Contracts and Grants</td>
<td>7-8</td>
</tr>
<tr>
<td>Publications and Patents</td>
<td>8-11</td>
</tr>
<tr>
<td>Presentations and Specifications</td>
<td>11-12</td>
</tr>
<tr>
<td>Program Summary Chart</td>
<td>12-14</td>
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</tbody>
</table>
PURPOSE

1. To identify the chemical research and technology required for solutions to problems of national urgency, synchronous with the aeronautics and space effort.

2. To conduct both basic and applied interdisciplinary research on chemical problems, mainly in areas of macromolecular science and fire research.

3. To provide productive liaison with the engineering community and effective transfer of technology to other agencies and industry.

SCOPE

1. **Transportation safety in human environments:**
   a. Fire control in vehicles and structures.
   b. Development of high performance aircraft tire and brake materials.
   c. Development of high temperature elastomers for fuel tank sealants for advanced supersonic and conventional aircraft.
   d. Fire extinguishing methods.
   e. Toxicity studies of fire-retardant materials.

2. **Space exploration and advanced aircraft progress:**
   a. Development of advanced aerospace materials.
   b. Materials for environmental extremes--Entry Thermal Protection.
   c. Fire-resistant functional nonmetallic materials for aircraft applications.

3. **Technology utilization and application for civil applications:**
   b. Development of fire-protective coatings for LPG railroad tank cars.
   c. Development of improved brake linings for heavy duty use automotive vehicles and trucks.
   d. Development of refurbishment techniques for railroad ties.
   e. Development of high rise building fire safety concepts.
   f. Pollution control studies for internal combustion engines and other power plants.

ACCOMPLISHMENTS

1. **Research Achievements:**
   a. Discovery of new energy transfer process in macromolecules.
   b. Identification of nitro-aromatic amine derivatives as intumescent agents.
   c. Establishment of new techniques and materials for analytically modeling of polymer pyrolysis processes.
   d. Spectroscopic characterization for indole charge transfer process.
   e. Microstructural changes in diene polymers during pyrolysis.
   f. Identification of new thermochemical mechanisms of flame inhibition resulting from spectroscopic studies of hydrogen halides in diffusion flames.
   g. Identification and characterization of silicon carbide as the major char component of the Apollo spacecraft heat shield after entry.
ACCOMPLISHMENTS

h. Development of thermally stable polymers from the reaction of N,N' Bis(p-nitrophenyl) sulfamide and p-Benzoquinone dioxime acid mixtures.
i. Discovery of the linear correlation of the association constants of 1:1 complexes of methoxy amphetamines and 1,4 dinitrobenzene to the threshold hallucinogenic dose in humans.
j. Discovery of the effectiveness of gellant polymer-water system (polyacrylamide formulated with suitable scavengers for fuel components) to control hypergolic fires of \( \text{N}_2\text{O}_4 \) and hydrazine.

2. Developments:
a. Development of fire-retardant foams:
   (1) Semi-rigid urethane(5I).
   (2) Reinforced urethane(5I-10AQ-B, 5A-43).
   (3) Semi-rigid isocyanurate.
   (4) Flexible neoprene modified urethane.
   (5) Low and high density polybenzimidazole.
   (6) Low density polyimide.
b. Development of intumescent fire-retardant formulations:
   (1) Coatings for structural protection and for thermal-protection of weapons.
c. Basic parameters for new dangerous drug detector.
d. Ablative and thermal structures for LEM.
e. Development of isocyanurate foam-intumescent coating system and concept to increase survivability in aircraft ground crash fires.
f. Development of low density 5A43 reinforced urethane-composite system to protect Navy aircraft from fires initiated from incendiary projectiles.
g. Development of new brake lining materials based on high temperature polymeric composites with improved performance characteristics.
h. Development of non-smoking fire-resistant foams (polyimide and polybenzimidazole).
i. Development of fire-resistant, char-forming clear polymers, i.e., phenolphthaline polycarbonate, and cured tetrafunctional epoxy resin for application as windows and canopies for aircraft.
k. Development of bismaleimide resin composite structures; development of room temperature cure bismaleimide coatings.
l. Development of low cost polybenzimidazole prepolymer.
m. Development of low density polybenzimidazole foam for cryogenic and high temperature insulation applications.

3. Applications:
a. Application of intumescent coatings adjacent to center jet engine of Lockheed L-1011 aircraft to protect aircraft structure from jet engine fires.
b. Application of urethane foam in the intergral fuel tank assembly of Navy A-4 aircraft to achieve fuel systems cook-off protection against carrier deck fires and to reduce ballistic threat levels and in the wing fuel tank of Marine A-4 aircraft to reduce ballistic
ACCOMPLISHMENTS

- Application of intumescent coatings and urethane foam to the F-15 Gun System to prevent catastrophic explosions resulting from fire and fire propagation of ignited rounds.
- Application of intumescent formulations to explosive devices and missiles to achieve cook-off protection against fires (U.S.N. 500 lb. bombs, Sidewinder missile and 20 mm gun pod).
- Application of intumescent formulations and urethane foam for thermal protection of the Space Shuttle Vehicle during ascent phase.
- Application of bismaleimide laminate-polyimide foam composite structures as fire-resistant bulkheads for crash-fire protection of aircraft.
- Application of fire-retardant foams as acoustical insulation for aircraft.
- Utilization of Ames fire-resistant materials in the MSC 737 test program.

ENGINEERING EVALUATION TEST GROUP

Activities:

1. Analysis of materials applications problems:
   a. Identification of application requirements and constraints for advanced aerospace materials.
   b. Selection of combinations of key properties required for specific applications.

2. Design testing programs to evaluate materials for specific applications such as fire protection of commercial and military aircraft:
   a. Establish materials use specifications and design criteria for utilization of fire-retardant materials in aircraft.
   b. Develop screening programs for specific materials.

3. Conduct thermal, mechanical and other tests needed to screen materials developed by Chemical Research Projects Office:
   a. Measurement of thermal properties of high-temperature materials, and fire-resistant materials.
   b. Measurement of the mechanical properties of advanced aerospace materials.

4. Provide metallic and non-metallic materials physical testing as a service function for other research activities at the Center.

5. Conduct environmental and physical testing of state-of-the-art commercial materials and present results for comparison with NASA-produced materials for in-house evaluation.

POLYMERIC MATERIALS DEVELOPMENT GROUP

Activities: Development of polymeric composites.
1. Material and process development and pilot level production of non-metallic materials for evaluation and other test programs.
3. Preparation of nitroaniline derivatives for intumescent coatings.
4. Preparation of polyisocyanurate, polyurethane and polyimide foams.
5. Preparation of bismaleimide composites and room temperature cured fire-resistant coatings based on copolymers of bismaleimide and acrylonitrile.
6. Development of char-forming fire-resistant clear polymers for aircraft windows and canopies.
7. Preparation of preliminary materials and process specifications for materials developed.

CHEMICAL KINETICS AND ENGINEERING GROUP

Activities: Chemical kinetics, thermal-oxidative degradation of polymers and catalytic studies.
1. Chemical Kinetics:
   b. Kinetics studies of reactions in organic systems such as energy transfer and quenching reactions of halogenated hydrocarbons and scission and cross-linking reactions of polymeric materials.
   c. Development of solid fire extinguishing compounds i.e., definition of mechanism of fire extinguishing action of solid fire extinguishers for jet engine fire and definition of efficiency of fire extinguishment of existing and new solid fire-extinguishing compounds.
2. Thermal degradation studies of polyphenylene and other high temperature polymers by electron spin reconance; studies of the pyrolysis and offgassing products of high temperature polymers.
3. Methanation studies of hydrocarbon fuels for reducing polution of emissions produced from internal combustion engines and other power plant systems; studies of catalytic surfaces.

SEALANT PROJECT TEAM

Activities: Development of high temperature elastomers for aircraft fuel tank sealants.
2. Study of thermal degradation and stress relaxation of candidate sealants.
4. Development of analytical models for prediction of sealant service life.
5. Compounding and evaluation of dynamic and thermophysical properties of filled sealants.
7. Evaluation of sealants using simulated flight tank assembly.
8. Pilot production, processing, and compounding of candidate sealants.

**CONTRACTS AND GRANTS**

**Current:**
1. Study for synthesis of optically clear polymeric materials for high-temperature windows; Dow Chemical Co., NAS2-6388.
2. Design, development and delivery of a prototype protable detector of morphine in urine; Whittaker Corp.
3. Development and Evaluation of room temperature curing, fire-resistant coatings based on selected bismaleimides; Battelle Memorial Institute, NASW-1948.
5. Study of refractory modified high temperature structural composites, synthesis and properties; Lockheed Aircraft Corp., Lockheed Missile and Space Co., NAS2-7060.
6. Characterization of polybenzimidazole composite foams; Whittaker Corp. R and D Division, NAS2-7112.
7. Study of oxygen atom recombination on quartz surfaces; Stanford Research Institute, NAS2-6776.

**Completed:**
1. A study involving the characterization, synthesis and production of polybenzimidazole prepolymer; ESSO Research and Engineering Co., NAS2-6159.
2. Theoretical and experimental investigation of ignition and combustion mechanisms in polymer materials in both air and enriched atmospheres; Marshall Industries, NASW-1921.
3. Research on toxicity of pyropysis products of foams, intumescent coatings and Fluorel; University of Utah, NAS2-6063.
4. Study to formulate intumescent coating compositions; Hughes Aircraft Co., NAS2-6349.
5. Synthesis, physiochemical and biological measurements of a series of indole compounds; University of San Francisco, Grant NGR-05-029-066.
6. Kinetics of reaction of the by-products of ablative materials; Stanford Research Institute, NAS7-472.
7. Fire protective materials application program; AVCO Corporation, NAS2-5428.
8. Synthesis of organic compounds containing nitrogen; Dow Chemical Co., NAS2-4893.
9. Study and production of polybenzimidazole laminates and billets; Lockheed Missiles and Space Company, NAS2-5521.
10. Study to fabricate encapsulated halogen-containing compounds; National Cash Register Company, NAS2-4886.
11. Ablation testing of PBI; Aerotherm Corporation, NAS2-5794.
12. Synthesis of nitro-aromatic amine compounds as intermediates for intumescent coatings and polymers; Dow Chemical Company, NAS2-4893.
13. Fire-retardant foam materials testing program; Lockheed Aircraft Corporation, NAS2-4815.
15. Thermal control coatings systems; Dyna-Therm Corporation, NAS2-3237.
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<td>Polydimethylphosphonitrile polymers as thermal control coatings;</td>
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<td>Study of low density fire-retardant materials; University of Utah, NAS2-5553.</td>
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<td>Thermophysical and chemical characterization of charring ablative materials; Battelle Memorial Institute, NAS7-342.</td>
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<td>Experimental and analytical studies of radiation-only pyrolysis of model char forming polymers;</td>
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<td>A review of oxidative degradations of certain heterocyclic polymers; Stanford Research Institute, NASA-6464.</td>
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<td>Study to optimize gellant polymer-water systems for control of hypergolic fires; Dow Chemical Company, NAS2-6532.</td>
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<td>The synthesis of monomers for high-temperature resistant polymers; Wartburg College, Grant NGR16-005-001.</td>
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<td>Formulation and production of intumescent coating compositions; Hughes Aircraft Company, NAS2-6387.</td>
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<td>Material Screening test program, Aerotherm Corp., NAS2-5794.</td>
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**PUBLICATIONS AND PATENTS**

5. Griffin, R. N., Jr., and Beck, C. W. III: Description of Ames Research
PUBLICATIONS AND PATENTS


22. Poskhus, A. C., and Parker, J. A.: Studies on Nitroaniline-Sulfuric Acid
PUBLICATIONS AND PATENTS


33. Golub, M. A. and Gargiulo, R. J.: Thermal Degradation of 1,4-Polyisoprene and 1,4-Polybutadine. Polymer Letters, 10, 41 (1972).


PUBLICATIONS AND PATENTS


PRESENTATIONS AND SPECIFICATIONS


21. Fish, R. H. and Parker, J. A.: Relationship of Molecular Structure and Thermochemical Char Yield on the Thermal Properties of Foamed Polymers, Presented at the SAMPE meeting, Los Angeles, California, April 1972.


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