COMBINATORIAL APPROACHES TO CHEMISTRY RESEARCH

INDUSTRY PROBE WORKING GROUP DISCUSSION

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I. Executive Summary

The purpose of this Working Group Discussion was to collect data and stimulate input on industry needs for an ATP Focused Program on combinatorial ("high through-put" or "massively parallel") methods or applications in the chemical or materials industries. Thirteen representatives of industry and six representatives from NIST participated in this Working Group Discussion. John Hewes, ATP Project Manager, facilitated the meeting. All of the industry representatives had technical backgrounds and two represented non-R&D departments. Their fields of interest included marketing, chemicals and materials research, software, and venture capital.

Professor Peter Schultz (University of California at Berkeley and Symyx Technologies) presented the state of the art in technology. The major opportunity identified was in infrastructure development. The big issue presented was a need for the sharing of multiple solutions due to the very high entry costs. Technology opportunities for combinatorial discovery in chemicals and materials were then brainstormed. The major technology needs/enablers identified by the participants were: library design, materials deposition, processing, library validation, screening, database / informatics, and foundation (core) technologies. Sensors development was identified as the major bottleneck due to the size and complexity of analyses required for screening materials to multiple customer or process requirements.

Isy Goldwasser (Symyx Technologies) presented market opportunities. Potential markets were subsequently brainstormed with all participants. The (non-pharmaceutical) industries identified by the participants were: polymers, catalysts, electronic materials, specialty and fine chemicals, bio-materials, optical materials, structural materials, and products for combinatorial end-users. The markets with the biggest hits were identified by the participants as being in the catalyst and electronic materials industries.

A Strengths/Weaknesses/Opportunities/Threats (SWOT) Analysis was conducted. Major threats observed were foreign competitor entry. The major weaknesses were the need for a culture change in the research community and high cost of entry. Huge opportunities were identified based on core strengths spilling over from the pharma sector as well as in foundation technologies such as sensors and robotics.

Why ATP? The participants said that ATP could catalyze broad U.S. involvement in this area. Market pull for new materials, cost reduction, new and improved products, reduced cycle time for innovation, building the infrastructure industry supporting combinatorial methods, increased productivity of R&D dollars, etc. are the major issues that industry may want ATP to address. This represents a paradigm shift toward cycle time reduction in innovation that would support critical industries, and allow U.S. industry to gain global market share.

Can we do it? The major issue presented by the participants at this meeting concerned the entry by non-US competitors with their core competencies. Based on the success of the pharma industry, there is high probability of US success in combinatorial materials development pending resolution of key issues identified. Entry into combinatorial development will be capital- and personnel-intensive. The high cost of state-of-the-art equipment, as well as the need for highly multi-disciplinary teaming, through intra- and inter-company alliances, will limit entry in some industries.

II. PURPOSE OF MEETING

The purpose of this Working Group Discussion was to collect data and stimulate input on industry need for an ATP Focused Program on combinatorial ("high through-put" or "massively parallel") methods or applications in the chemical or materials industries.

III. PARTICIPANTS

Thirteen representatives of industry and six representatives from NIST participated in this Working Group Discussion. John Hewes, ATP Project Manager, facilitated the meeting. All of the industry representatives had technical backgrounds and two represented non-R&D departments. Their fields of interest included marketing, chemicals and materials research, software (environmental and catalysis-modeling), and venture capital.

IV. QFD ANALYSIS OF MARKETS AND TECHNOLOGIES

A detailed list of technologies is compared with potential markets in a Quality Function Deployment (QFD) –type of worksheet (MS Excel v. 7.0 spreadsheet) on the ATP web site http://www.atp.nist.gov/atp/focusprg.htm#Proposed. Participants were invited to return a completed matrix by e-mail to ATP (john.hewes@nist.gov) indicating the relative phases of the enabling technologies for their industry, that is, *pacing* (more than five years from commercial use = 9), *key* (from 2-4 years from commercial use =3), and *base* (within one year of commercial use = 1). The matrix will be used as one input to define program scope limits by identifying those markets with the greatest potential for economic pay-back correlated to the technologies that will enable those opportunities. The matrix analysis will be iterated during the ATP Workshop for Focused Program development, with input from a variety of technical and business experts from private industry, academia, and Federal government. Synergies between markets and technologies should be identified and input into ATP from industry, academia, and Federal Labs. The goal is to develop a market-product-technology roadmap prior to Program Recommendation.

A. Brainstorming I -- Market Opportunities

Market opportunities were explored with the participants. Opportunities identified were limited to non-pharmaceutical applications due to non-enabling status of combinatorial chemistry in the pharma/ag chemical industry. The industries identified were: polymers, catalysts, electronic materials, specialty and fine chemicals, bio-materials, optical materials, structural materials, and products for combinatorial end-users. More detailed applications within these industries are identified in the accompanying spreadsheet.

B. Brainstorming II-Technology Needs

Technology needs to attain combinatorial discovery in chemicals and materials were brainstormed by the participants. The major technology areas identified were: **Library Design**; **Materials "Deposition"**; **Processing**; **Library Validation**; **Screening** (physicochemical properties, molecular properties; physical properties; mechanical properties and polymer architecture; optical characterization; manufacturability); **Database / Informatics**; and **Foundation Technologies** (robotics, informatics).

V. SWOT ANALYSIS OF COMBINATORIAL CHEMISTRY TODAY

A. Strengths	B. Weaknesses
❖ cycle time reduction ❖ cost effectiveness ❖ more alternatives earlier ❖ prior experience in pharma ❖ scope of opportunities ❖ information (success or failure) is good ❖ maximizes serendipity ❖ adaptable for discovery and for optimization	❖ doesn't fully address synthesis hurdles ❖ high entry costs ❖ technology stretch // high risk ❖ long lead time to fully integrated system ❖ cultural backlash (technical & business communities) ❖ requires strength in multiple disciplines (very difficult for small companies) ❖ difficult to protect intellectual property ❖ no guarantee of success ❖ lose serendipity aspects of current research
C. Opportunities	**D. Threats**
❖ new products in significantly less time ❖ develop broad base of technologies ❖ expand chemical information base ❖ develop new businesses in combinatorial ❖ better protection of US industries and technologies ❖ To be FIRST to market, to continue to lead in global technology race	❖ Needs demo to prove worth ❖ Coordination to integrate all efforts quickly ❖ US leadership could change face of innovation ❖ First generation stage of the technology -- need to focus on how future generations will look ❖ Creation of automation experts ❖ International (Japan & Germany) ❖ empirical approach fits non-US core competency ❖ material science core expertise ❖ miniaturization, automation, databases

VI. OPEN DISCUSSION OF MAJOR ISSUES

A. Why ATP?

Participants felt that industry conservatism is the reason for ATP: ATP can catalyze broad US involvement in this area. Market pull, cost reduction, new and improved products, reduced cycle time for new products and services, increased productivity for R&D dollars, etc. are the major issues that ATP can address. This is a paradigm shift that will support development of critical infrastructural/core industries, with broad economic benefits through technology spillovers and partnerships, and allow the US to compete better globally.

The industry participants said that this is a "show me" arena –U.S. industry is waiting for first-to-market opportunities before proposing combinatorial-based R&D to their own management: ATP's money will be invested in reducing the time to get to the "Show Me", i.e., minimizing the impact of competition developing combinatorial techniques for materials discovery. By the end of year, people will take notice (Symyx will have several global partners in the chemicals arena in 1998), and the debate will shift from "will this help me" to "will this hurt me". For example, look at metallocene catalysts and what happened there -- $1B per year is being spent there now--but it took some high risk up front by a few companies to initiate R&D activities. ATP needs to make a few of these positive examples of combinatorial materials development occur *in the U.S.* – the show me factor.

B. Can we do it?

The major issue presented by the participants at this meeting (as also presented in the SWOT analysis) concerned the rapidity with which non-US competitors will (and are starting to) adopt this technology based on their strengths and core competencies. For example, a cultural acceptance of empirical research, a multi-disciplinary approach to innovation, government financial assistance, significant strengths in materials development, and strong competencies in miniaturization favor Japan, Germany, and others. The U.S. R&D community will have to undergo a culture change to accept combinatorial materials development: industry R&D culture will have to change from a CRAFT to a PROCESS -- might appear at first to eliminate jobs, however the overall growth of jobs should be significant. However, participants stressed that an empirical approach by itself will not solve most problems, and that an *a priori* approach, for example using computational methods, will be required for preliminary library design and analysis.

Entry into combinatorial materials development will be capital-intensive. The high cost of state-of-the-art equipment, as well as the need for highly multi-disciplinary teaming, will drive development of infrastructure (software, hardware, services, etc.) using networks and alliances, with consequentially large spill-over potential.

VII. POTENTIAL ATP PROGRAM: INFORMATION NEEDED

- Current and planned industry investment in combinatorial R&D (domestic and foreign) over the next 2-4 years?
- Other federal programs and investments: positive overlap needed
- Is a $70M (approximately $10M/year ATP funding over 3-5 years with industry cost-share) per program budget “right sized” for this industry effort?
- Scope definition (technology and market opportunities) and solicitation strategy
- What are the cultural barriers to US leadership in this area and change management implementation?

VIII. ACTION ITEMS

A. ATP Program Selection Process

1. QFD spreadsheet in MS Excel 7.0 to be returned to john.hewes@nist.gov
2. Working Group Report by end of March -- out to participants
3. QFD input from industry to ATP (April 15)
4. Industry white paper inputs from industry-- markets and challenges (April – July)
5. ATP consolidates industry input into working White Paper (June – July)
6. Technology Probe Working Group Discussion @ NIST (early July)
7. ATP program recommendation draft out for industry evaluation (mid- July)
8. “Dry Run” internal to ATP (mid-July) and Review (Aug 4-6)
9. Public Workshop (early-Sept.)

IX. Appendix

A. List of Attendees

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B. ATP Program Development Process and Timeline for Fall 1998 Recommendation

TASK	**INPUT** Market Pull & Technology Push →	Program Ideation →	ATP Programs Selected →
SUB-TASK & TIMING	-Working Group Disc. at NIST -March 24 -ATP publishes report on Discussion -March 31 -Industry submits White Papers to ATP -March - May	-ATP consolidates working white paper -April - May -ATP publishes White Paper -June 1 -Additional industry inputs: scope and fit -July 1 -ATP Program Manager publishes revised White Paper -July 5 -ATP Public Workshop develops roadmap -early Sept.	-Proj. Manager submits synopsis to ATP Office Director -July 5 -Dry run presentations to ATP staff -July 20-21 -ATP Management Review -July 28 -Outside Reviewers evaluate -Aug 4-6 -Programs announced (CBD, Fed. Reg., etc.) -Sept. - Oct.
METRIC	-Why ATP? -Investment needs -US economic benefit -Market opportunities -Industry commitment -Technical challenges	-Est. Commerical Value (>industry) -US vs ROW competition -ATP portfolio synergies -US strategic fit	-ECV (>spillover) -US vs ROW competition -ATP portfolio synergies -US strategic fit -Broad-based social benefit ($)

C. Presentation Slides

D. Sample White Paper

A sample White Paper will also be available on the ATP Focused Program Development Web site for Combinatorial Chemistry.

E. Market vs. Technologies Matrix (MS Excel 7.0 attachment)

The Markets vs. Technologies matrix will be available in electronic form on the ATP Focused Program Development Web site for Combinatorial Chemistry.

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