MICHIGAN GREEN CHEMISTRY ROUNDTABLE
Defining the Parameters of the Green Chemistry Program

RECOMMENDATIONS

Background

Executive Directive No. 2006-6 (Directive) establishes a Green Chemistry Roundtable (Roundtable) and a Green Chemistry Program (Program). A Roundtable is established that will advise the Department of Environmental Quality (DEQ) on the structure of a Program and the means for which it will carryout its principal duties, as articulated in the Directive.

Prior to the Roundtable's formation, the DEQ consulted with various stakeholder groups regarding action items and priorities. The document entitled "Advancing Green Chemistry: An Action Plan for Michigan Green Chemistry Research, Development, and Education" (Action Plan) was an outcome of those discussions. This Action Plan lays out a course and timeline for building the Program and making it sustainable.

Request

With this in mind, the DEQ asked the Green Chemistry Roundtable Workgroup 1 to review and recommend parameters for the Program, and the metrics and means for measuring success.

Summary of Charge

This workgroup is charged to address Actions 1 and 2 in the Action Plan in the following order of priority. This document addresses the first Action item in the Action Plan.

Action 1: "Define the Scope and Priorities of the Green Chemistry Program"
For this action, the DEQ has asked the workgroup to develop a proposal that defines:

- The objectives of the program;
- The activities of the program;
- Boundaries for the activities undertaken by the program; and
- The metrics and means for measuring success.

Response

The workgroup segmented the assignment into three parts: establish a framework for the discussion, understanding the definition of Green Chemistry and its principles, and understanding the nexus between Green Chemistry and Sustainable Chemistry. First, the workgroup considered a set of threshold questions regarding the intent of the Green Chemistry Executive Directive. The workgroup felt it necessary to address these

questions before it could construct meaningful recommendations for the parameters of the Green Chemistry Program. Given this, the workgroup sought consensus among its members on:

- What is the definition and scope of green chemistry proposed for the Green Chemistry Program?
- What is meant by "Green"?
- What is the relationship between Green Chemistry and Sustainable Chemistry?
- Should the recommendations address the environmental impacts of chemicals on human health, ecosystem health, or both?

Some specific questions related to these issues under consideration included:

- Is the intent of green chemistry to improve the environmental impact of the manufacture and use of chemicals or does green chemistry also cover the application of these chemicals in products (irrespective of the environmental impacts of the chemicals themselves)?
- Should the application of green chemistry be limited to the manufacture of chemicals or does the scope include the impact of chemicals during other life cycle stages of a chemical, e.g. use in products, and end-of-life?
- Does the use of the chemical to improve the environmental performance (e.g. energy performance) of a product constitute green chemistry, even if the chemical itself is hazardous?
- Is environmental improvement ("greenness") limited to reduction in hazard, or should other life cycle impact categories (e.g. resource depletion, global warming, ozone depletion etc.) also be considered?
- What is the benchmark for environmental improvement ("greenness") or reduced impact on human health, ecosystem health, or both?

The workgroup's deliberations on these questions were informed by some definitions that have been proposed previously:

Three proposed definitions of Green Chemistry:

- Green chemistry is the **design** of chemical products and processes that reduce or eliminate the **use and generation** of **hazardous substances**[1].
- "Green chemistry" means chemistry and chemical engineering to **design** chemical products and processes that reduce or eliminate the **use or generation** of **hazardous substances** while producing high quality products through safe and efficient **manufacturing processes**[2].
- Chemistry and chemical engineering is the **design** of chemical products and processes that reduce or eliminate the **use or generation** of **hazardous substances** through safe and efficient **manufacturing processes**[3].

[1] Anastas, Paul T., and Warner, John C. *Green Chemistry: Theory and Practice*, Oxford University Press, New York, 1998

[2] Executive Directive No. 2006-6: *Promotion of Green Chemistry for Sustainable Economics Development and Protection of Public Health.*

[3] Green Chemistry Research and Development Act of 2005 [HR 1215]

All the above definitions share key terms delineating the scope and boundaries of green chemistry:

- **Design** and **manufacture** stage of chemicals **products** and **processes; and**
- Reduction in the **use and generation** of **hazardous substances.**

In all cases, "reduction in hazard" is stated as the defining criterion for "greenness" in green chemistry. Reference to the source of the first definition[4] reveals the intent of green chemistry is about redesigning organic chemistry such that "hazard is a design flaw". In this context, "chemical products" refers to the final products of a chemical reaction, and not consumer products in which the chemicals are used; processes refers to the synthesis reaction to make the chemical product.

Principles of Green Chemistry
The above definitions are qualified by or expounded upon by a set of twelve principles. In fact, Executive Order 2006-6 adopts the set of principles verbatim from the source for the first definition. Reference to the original source of the set of principles[1] reveals the primary intent of the principles: each principle is, for the most part, a strategy to achieve the defining criterion of green chemistry, i.e. reduce hazard. Principles are themselves not definitions, but strategies/guidance to help meet the definition.

Green Chemistry and Sustainable Chemistry
The workgroup next examined the nexus between Green Chemistry and Sustainable Chemistry to ascertain a relationship, and assess the benefits of integrating Sustainable Chemistry principles into the Green Chemistry Program's goals and objectives.

Two definitions of "Sustainable Chemistry" were considered:

- "*Sustainable chemistry is chemistry that is environmentally friendly, minimizes waste generation and energy use, and preferentially uses renewable raw materials such as agricultural products instead of fossil resources such as crude oil or natural gas"*[5] and
- "*Sustainable chemistry is the design, manufacture and use of efficient, effective, safe and more environmentally benign chemical products and processes".*[6]

Some confusion can arise from the fact that the OECD[6] considers sustainable chemistry (as defined above) as synonymous with green chemistry. However, this is not the definition of green chemistry adopted by Executive Order 2006-6 or pending federal legislation.

[4] Anastas, Paul T., and Warner, John C. *Green Chemistry: Theory and Practice*, Oxford University Press, New York, 1998
[5] Royal Belgian Academy Council of Applied Science: *Industrial Biotechnology and Sustainable Chemistry;* January 2004
[6] Organization of Economic Co-operation and Development

Key differences in the scope of green chemistry (as defined) versus sustainable chemistry (as defined) are that:

- Sustainable chemistry recognizes environmental improvement in multiple life cycle impact categories; it does not specifically limit the defining criterion to "hazard reduction". Hazard reduction means reduction in the hazard potential of chemicals, substances or waste that (1) are toxic; (2) are corrosive, ignitable, explosive, or chemically reactive; or (3) adversely impact human health and/or the environment. Such chemicals, substances and wastes are typically defined as being "hazardous". Instead, it uses general terms such as "environmentally friendly" or "environmentally benign".
- By inference, sustainable chemistry may be interpreted as having a broader scope on how environmental improvements are achieved:
    - It is not specifically limited to select life cycle stages; and
    - It considers both the environmental performance of chemical manufacture and the application of chemical in products.

None of the above definitions limit the scope of green chemistry and sustainable chemistry to environmental improvements that specifically benefit only human health or ecosystem health.

Recommendations

Therefore, it is the recommendation of Workgroup 1 that the DEQ define the scope and boundaries for the Green Chemistry Program as such.

- The Program will have a perspective that considers all the stages of the life cycle of a chemical.

- The principal focus of the Green Chemistry Program will be on "hazard reduction" as the primary impact category of interest in each life cycle stage with a focus on the design stage. However, the Program will consider other life cycle impacts of innovation.

- The Program's intent is to reduce hazards to human and ecosystem health.