Pollution Prevention through Property-Based Design

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There is a growing need to develop cost-effective process and material design methodologies that foster resource conservation and pollution prevention for the chemical processing industry. The efficient use of resources is a key element of sustainable development, whereas material selection becomes an important task in process design. Towards this end, an integrated and generally applicable framework is an essential feature in designing process systems that can enhance sustainability. Recently, the role of property-based research in prevention pollution has been highlighted. While the role of mass and energy integration has been acknowledged as a holistic basis for sustainable design, it is worth noting that there are many design problems that are not component dependent. These problems would be adequately addressed by focusing on properties or functionalities instead of chemical compounds, since these properties would guide the selection and use of the optimum materials for enhanced process performance at the earlier design stage. Therefore, an integrated property-specific design methodology would be useful in identifying new material substitution strategies for pollution prevention, resource conservation options and overall process integration.

This work introduces a property-based holistic approach to the identification of pollution prevention strategies and resource conservation options. In particular, we focus on new property-based methodological approaches for material substitution that target the objectives of minimum pollution and maximum consumption of process resources. Material design for viable applications can become a powerful means in reducing the usage of toxic and pollution-causing agents. Therefore, this work demonstrates the utility of the revised property-based design to provide a natural framework for material selection in process systems. It also aims at generalizing and integrating the component-less with the existing component-based mass integration techniques. Process constraints and stream characterization are described using bounds on properties, whereas graphical representations are used to integrate the various sources, sinks and molecular groups. This approach also provides useful insights on identifying new molecular structures and process routes for material substitution. Finally, a case study is presented to illustrate the applicability of the developed approach.