Fusing green chemistry and green engineering: DesignBuild at the molecular level

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At the end of June, 2008, our journal, *Green Chemistry*, will be holding a reception to celebrate the tenth anniversary of the first issue of the journal. It is notable because the reception will be held at the annual Green Chemistry and Engineering Conference in Washington, D.C. For those who have not attended the conference previously (I encourage you to do so this year and stop by the reception), I would note that it regularly receives an outstanding review by its attendees because of the interdisciplinarity that is ingrained even in the conference title. The importance of the inclusion and fusion of the various talents needed for the generation of science and technology for sustainability cannot be overstated.

It is said that the concept of a Master Builder can be traced back to the Code of Hammurabi in Mesopotamia in 1800 B.C. Since the inception of this model, the Master Builder has been responsible for the erection of everything from temples, to bridges, to municipal building, to castles, to skyscrapers throughout millennia. It was the case that the role of Master Builder was almost always filled by an architect or some close equivalent of an architect, and the construction experts were only brought in to implement the design plans of the Master Builder. In recent decades, the concept of DesignBuild has been increasingly used as an alternative to the Master Builder model. DesignBuild brings together the designer (architect) and the builder (construction experts) in an integrated manner. The advantages of this new approach have been compelling enough to result in the DesignBuild approach being adopted in the majority of the projects in the E.U. and North America.

This architectural analogy can be particularly instructive for what needs to happen in the field of green chemistry. Since the field of chemistry emerged in its modern form, the molecular architects, the chemists, have designed chemicals to have the properties, the performance and the capabilities that they desire them to possess. The chemist Master Builder would then engage the expertise, such as chemical engineers, needed to bring the new chemicals to scale. This model has been effective in producing molecules that can cure disease, provide energy and be the basis of new materials. It is also important to recognize that this process has been in place during the time in which many concerns have arisen about the effects of chemicals on the environment and human health. In order to fully understand these issues, and more importantly address these issues, requires the full integration of other essential disciplines such as engineering, exposure and fate, and toxicology.[1] In other words, the DesignBuild model needs to be incorporated as a central approach in the field of green chemistry.

It has often been said that the field of green chemistry is inherently interdisciplinary.[2] While there is some truth to this statement because green chemistry deals with performance criteria beyond those typical physical/chemical properties and narrow measures of efficiency historically used to evaluate the quality of our chemistry, there is still much room for improvement in the implementation of DesignBuild in the practice of chemistry. Green chemistry is well poised to lead the way in this important evolution in the molecules that we make and the way we make them.

There have been important developments in recent years that demonstrate how the field of green chemistry is moving toward this integrated interdisciplinary model. Several years ago, the University of Nottingham launched a program that illustrated how chemistry, engineering and important communication disciplines could work together on issues of sustainability. The DICE model, Driving Innovation in Chemistry and Chemical Engineering, has served to show the importance and the productivity of interdisciplinary integration. No longer would it be acceptable that a new molecule be designed or a new synthetic process be discovered and then tossed over the transom to the chemical engineers to scale-up. The inefficiencies, the rework and the unforeseen consequences of that approach were too numerous and too well-documented to continue with that process. The DICE model is one for others to look at, emulate, and hopefully improve upon as we seek to implement DesignBuild for chemistry.

A little over a year ago, Yale University launched the Center for Green Chemistry and Green Engineering in the Department of Chemistry, the Department of Chemical Engineering and the School of Forestry and Environment. The Center also has on its Board representatives from the Schools of Medicine, Law, Management, Architecture and Divinity. While we are moving toward a more complete integration of the chemical design process, there is a long way to go. We need to have the molecular designers, process designers, product designers, and expertise on all life-cycle stages present at the design table—if not in person then at least their knowledge base needs to be represented.

DesignBuild for chemistry may very well show the type of efficiencies, performance benefits and innovations for our field as it has in the building and infrastructure trades. At a minimum, it should be valuable in avoiding the unforeseen and undesirable consequences of our chemistry that is an important mission of green chemistry.

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References

1 William McDonough, Michael Braungart, Paul T. Anastas and Julie B. Zimmerman, *Environ. Sci. Technol.*, 2003, **37**(23), 434A–441A.
2 Rebecca L. Lankey and Paul T. Anastas, *Ind. Eng. Chem. Res.*, 2002, **41**(18), 4498–4502.

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