

Merging of the sciences and technologies

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Editorial

Merging of the sciences and technologies: non-technological barriers

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All experts share the same view that future eminent breakthroughs will be made largely at the interfaces of the sciences and technologies. Technology merging is one of the megatrends which are forecasted to shape society and the economy of the future.

I grew up scientifically in this “gap” and found myself from the first moment as a chemist among chemical engineers, mechanical engineers, and physicists. All these skills are needed for micro technology as a whole scientific package. The applications were as diverse as relating to the smallest motors, actuators, sensors, pumps, and microreactors, which was my topic. Lately, I helped to create this journal *Green Processing and Synthesis* which, first of all, crosses the borders of chemistry and chemical engineering. Yet and secondary, papers about material science, metallurgical technology, catalyst development, and more are included as well.

One striking problem we experienced when making the journal was that too few experts on the “inter-disciplines” are available. For the journal, this means in practice that it is here and there difficult to find the right referees. For industry being active in a technology-merging business this means it might be difficult to recruit the right personnel and there is a danger to dry out with the key knowledge. How are those everyday problems solved?

In the first case, a straightforward solution is to take two (or three, if needed) referees coming from the mono-disciplines most relevant for the content of a paper. All in all this is a workable approach, but experience shows that sometimes the communication might be difficult. If the author and referee are shaped by different communities and scientific worlds it might be that their vision on what is innovation can be miles away. Thus, it is always advised to look for a true interdisciplinary referee who is from the field. Actually, I usually prefer to have both a referee from a monodisciplinary and interdisciplinary field. That has shown to give the best outcome.

This learning can be transferred as well to the second case given above. When entering an interdisciplinary field (e.g. flow chemistry), industry assembles a team

with different skills, typically from the mono-disciplines. In the recent times, however, industry began requesting more and more the specialists with interdisciplinary backgrounds. These are difficult to find and therefore industry has given the quest to the academics to facilitate such access. On the podium discussion of the last FROST5 Conference (Frontiers in Organic Synthesis Technology, Budapest, October 2015) chemical industry asked the researchers to educate more students in flow chemistry to satisfy the increasing market demands.

For this, a change of the academic teaching curriculum is required, as there are hardly any courses on the inter-disciplines. The problem is that the curriculum is already full with mono-discipline courses. Any new insertion would mean a deletion of one of the classical topics. Moreover, the students themselves typically choose a curriculum which as a whole is aligned around mono-disciplines within a mono-field such as chemical engineering. Thus, it might be a challenge to educate chemical engineers with the theme of flow chemistry which pronouncedly needs some basic understanding of organic chemistry (and vice versa).

Thus, industry and individual research groups rapidly adapt to the inter-disciplines, while the faculties/universities and platform organizations take over these new technology mergers at a much slower speed. This may limit the growth of a technology and lead to insufficient exploitation of the theoretical potential. Recently the CHEManager Europe discussed the role of non-technological barriers for Green Chemistry and Engineering development (Barriers_to_Innovation, Chemanager Europe, 2013, 7–8, 12). All of this provides a chance for specialized teaching institutes, modern universities, consulting agencies, service providing companies, and any kind of public-private partnerships – to fill in the knowledge gap.

Yet, industry can also take a different approach to foster inter-disciplinary developments. The ACS Green Chemistry Institute Pharmaceutical Roundtable, with the major pharmaceutical companies participating, has published a priority list of key technology innovation drivers (Constable et al., *Org. Process Res. Dev.* 2007, 11, 133). Continuous processing and bioprocessing were set

as top-1 and top-2 positions, respectively. Additionally, the pharmaceutical industry has given their vision on needed improvements for current reactions and what the aspirational reactions of the future might be (Constable et al., *Green Chem.* 2007, 9, 411). This has involved R&D agendas throughout, e.g. of collaborative EU projects in the field of medicines. Moreover, and maybe most notably, the legislative authority, the FDA has aligned to that. This year, the FDA has announced a switch from batch to continuous for pharmaceutical production up to the year 2025.

Thus it may be concluded that in order to bridge between the disciplines a framing support is required and its first mission must be to remove all non-technological barriers. Seeing the strong impetus of the inter-disciplines,

it will be interesting to follow to where this leads within the next 20 years or so.



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