Editorial corner – a personal view

Hydrogen storage and polymers

*S. Fakirov**

Centre for Advanced Composite Materials, Department of Mechanical Engineering, The University of Auckland, Private Bag 92019, Auckland, New Zealand

Albeit the term ‘hydrogen economy’ was coined recently, the idea for combustion of hydrogen in a cylinder was suggested as an alternative to the steam engine as early as 1820. Hydrogen has a gravimetric energy density far higher than that of gasoline, coal, or methane. However, hydrogen has a very low volumetric energy density, and thus large steel tanks should be used in cars (for example a 250 liter tank, storing 4 kg hydrogen under 200 bar pressure, is needed for a drive of 350 km). To avoid this, two approaches are followed: i) chemical storage (using bound hydrogen in form of hydrides or ammonia), and ii) the physical storage (compressed, liquefied or adsorbed molecular hydrogen) (e.g. ISBN: 9780854045976).

For nanoporous materials as carbons, zeolites, metal-organic frameworks (MOFs), and porous polymers at temperatures close to that of liquid nitrogen are needed to store appreciable quantities of hydrogen. Maintaining this temperature in an on-board storage system is not convenient. Therefore, solutions for storage and release of hydrogen at ambient temperatures are required. Physisorption of gases, dominated by the interplay between surface area and changes in entropy and enthalpy, is promising; however, only nanopores at about 3 nm adsorb substantial amounts of hydrogen.

Porous polymers have several strategic advantages over porous carbons and MOFs: different reactions can be used for their synthesis, they are insensitive to ambient air, easier to handle, and mechanically more stable. Unfortunately, these materials also have

some disadvantages: their exact structures and pore sizes can hardly be assessed. Porous polymers adsorb water when exposed to the atmosphere, but they can be easily regenerated. The specific surface areas of cross-linked porous polymers may reach up to $1100 \text{ m}^2 \cdot \text{g}^{-1}$! The broad range of available monomers enables their flexible functionalizations. Polymers based on networks of aromatic rings adsorb the most hydrogen, both in total and per unit surface area. In particular, hypercrosslinked polystyrenes adsorb more hydrogen than poly(styrene-co-divinylbenzene) networks, even when the latter exhibit higher surface areas (<https://doi.org/10.1002/sml.200801762>).

Using polymers for hydrogen storage is a real challenge – a French company is constructing currently in Germany a ‘Hydrogen Train’ which starts operating in a year! (‘Die Welt’ of 20.09.2016). For this train hydrogen will be manufactured via electrolyse. What about the cars?

Prof. Dr. Stoyko Fakirov
Member of International Advisory Board

*Corresponding author, e-mail: s.fakirov@auckland.ac.nz
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