

X-ray diffraction analysis of the hierarchically porous product shows high angle reflections. This is new and important as it means that the structure is a single polycrystalline zeolite phase, which nevertheless retains a high degree of mesoporosity. Different zeolitic structures can, furthermore, be obtained by changing the composition of the reaction mixture and the mean size of the mesopores can be adjusted independently by changing the length of the alkyl tail or by varying the hydrothermal conditions in the reaction vessel.

Choi *et al.* then go on to demonstrate that, in catalytic reactions involving large molecules, their hierarchical nano/mesoporous zeolites are more effective than the corresponding bulk zeolites or zeolite-seed-assembled mesoporous materials. These enhanced reactivities are attributed to the combination of crystalline nanopores and uniform mesopores, although the mechanism of this enhancement is not yet established. Indeed, why nano/mesoporous zeolites show superior catalytic activities compared with polycrystalline zeolite-seed-assembled mesoporous materials is unclear, though it may depend on the mean sizes of the aggregated crystallites or their surface structures.

The authors tested one of their materials in a catalytic reaction for gasoline production and in two other syntheses of large organic molecules used in the pharmaceutical, fragrance and agrochemical industries. Once the preparation and structures are optimized, these materials may offer new opportunities for catalytic reactions or purifications involving larger molecules. These include polymers, long-chain hydrocarbons, enzymes and other large biomolecules, metal clusters for bifunctional catalysts and more, which have so far been unsuitable for use with bulk crystalline nanoporous zeolites, whose pore dimensions are generally too small to accommodate most macromolecular species. Such hierarchical nano/mesoporous zeolites are anticipated to offer new flexibility in the design and engineering of increasingly sophisticated heterogeneous catalysts for more diverse product targets and more-stringent efficiency and environmental process requirements.

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MATERIAL WITNESS

Tyred out



In July it became illegal to dump almost any kind of vehicle tyres in landfill sites in Europe. Dumping of whole tyres has been banned since 2003; now disposal of shredded tyres is also forbidden. That is going to leave European states with an awful lot of used tyres to dispose of in other ways. What can be done with them?

This is a difficult question for the motor industry, but also raises a broader issue about the life-cycle of industrial materials. The strange thing about tyres is that there are many ways in which they could be a valuable resource, and yet somehow they end up being regarded as toxic waste. Reduced to crumbs, tyre rubber can be incorporated into soft surfacing for sports grounds and playgrounds. Added to asphalt for road surfaces, it makes the roads harder-wearing.

And rubber is of course an energy carrier: a potential fuel. Pyrolysis of tyres generates gas and oil, recovering some of the carbon that went into their making. This process can be made relatively clean — certainly more so than combustion of coal in power stations.

Alternatively, tyres can simply be burnt to create heat: they have 10% more calorific content than coal. At present, the main use of old tyres is as fuel for cement kilns. But the image of burning tyres is unappealing, and environmentalists oppose the practice, disputing the claim that it is cleaner than coal. Such concerns make it hard to secure approval for either cement-kiln firing or pyrolysis. And the emissions regulations are strict — rightly so, but reducing the economic viability. As a result, these uses tend to be capacity-limited.

Tyre retreads have a bad image too — they are seen as second-rate, whereas the truth is that they can perform very well and the environmental benefits of reuse are considerable. Such recycling is also undermined by cheap imports — why buy a secondhand tyre when a new one costs the same?

Unfortunately, other environmental concerns are going to make the problem of tyre disposal even worse. Another European ruling prohibits the use of polycyclic aromatic hydrocarbon oil components in tyre rubber because of their carcinogenicity. It's a reasonable enough precaution, given that a Swedish study in 2002 found that tyre wear on roads was responsible for a significant amount of the polycyclic aromatics detected in aquatic organisms around Stockholm. But without these ingredients, a tyre's lifetime is likely to be cut to perhaps just a quarter of its present value. That means more worn-out tyres: the current 42 million tyres discarded in the UK alone could rise to around 100 million as a consequence.

Whether Europe will avoid a used-tyre mountain remains to be seen. But the prospect of an evidently useful, energy-rich material being massively under-exploited seems to say something salutary about the notion that market economics can guarantee efficient materials use. Perhaps it's time for some incentives?

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