ENERGY FOCUS

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Coated glass fibers could reduce waste energy

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Flexible glass fibers coated with fused PbTe nanocrystals act as thermoelectric materials that could conserve some of the nearly 60% of the energy that is generated or used in the United States that is lost as waste heat, according to Purdue University researchers. As reported in *Nano Letters* by Yue Wu and co-workers, glass fibers that were dipped in a PbTe solution containing only 5% Te and then annealed proved to be flexible enough to conform to complex shapes, while achieving an average figure of merit, *ZT*, of 0.75 at 400 K. Currently available thermoelectric materials, which have *ZT* ≤ 1, tend to be brittle and are, therefore, used in larger blocks. Also, because the PbTe coating thickness is only 300 nm in these experiments, much less of the thermoelectric material is needed for a given application.

Boron-doped carbon nanotubes make excellent oil sponges

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Doping multiwalled carbon nanotubes with boron causes them to form a networked porous "sponge" that loves oil and repels water, making it excellent for soaking up an oil spill in seawater. Lead author Daniel Hashim and his co-workers at Rice University and Penn State University reported in *Scientific Reports* that the carbon-boron multiwalled nanotube (CB_xMWNT) solids had an absorption capacity that was more than twice the capacity of the leading natural oil sorbent material. The CB_xMWNTs were formed by aerosol-assisted catalytic chemical vapor deposition with triethylborane as the boron source. The substitutional boron doping of the carbon nanotubes at B:C ratios as high as 0.25 led to "welding" of carbon nanotubes together through covalent bonding into a highly porous, mechanically strong three-dimensional structure. Analysis showed concentrations of boron in "elbow" defects in the nanotubes, which contribute to the structure's elasticity. Following absorption, the oil was burned off, making the sponge ready for repeated reuse without loss of mechanical properties.

Metal-organic framework saves energy in paraffin/olefin separations

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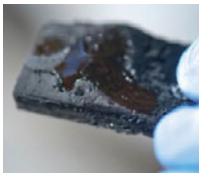
The plastics industry requires large volumes of pure ethylene and propylene to produce high-demand poly(ethylene) and poly(propylene). But these compounds must be separated from hydrocarbon mixtures derived from crude oil "cracking" at 500–600°C. Separation of paraffin/olefin mixtures (e.g., propane/propylene) is done by cooling to −100°C, followed by cryogenic distillation, requiring a huge energy input. In an effort to save most of this energy, researchers at the University of California–Berkeley, and the National Institute of Standards and Technology (NIST), led by Jeffrey R. Long, have developed a metal-organic framework (MOF) material to perform the separation at higher temperatures. The Fe_2(dobdc) MOF, where $dobdc^{4-}$ is 2,5-dioxido-1,4-benzene-dicarboxylate, can separate propane from propylene at 318 K because the Fe(II) coordination sites selectively adsorb the carbon–carbon double bonds of the olefin compounds. As reported in *Science*, flowing an equimolar propane/propylene mixture through a packed bed of the MOF at 318 K resulted in a stream of 100% propane in the exit gas, with all the propylene being adsorbed by Fe(II); similar results were obtained for an ethane/ethylene mixture. Desorption of the olefin from the MOF rendered the structure active for repeated separations.



Cross-section of the iron-based MOF bound to six ethylene molecules, as determined by neutron diffraction. *Credit:* NIST and Jeffrey Long.

High current density materials fabricated using a sol-gel process

Nature Mater. DOI: 10.1038/nmat3274

Researchers at Cornell University have developed a sol-gel process to fabricate thick films of silica whose pores can be filled with a wide variety of metals, making them suitable for use in fuel cells, battery electrodes, and solar cells. A silica film containing 36 vol% of Pd has a measured electrical conductivity of greater than 1000 S cm^{-1}, more than sufficient for use in high current density devices. For comparison, carbon-particle-based proton exchange membrane fuel cell electrodes have conductivities of ~0.5 S cm^{-1}. As reported in *Nature Materials*, Ulrich Wiesner, Scott Warren, and co-workers used amino acids, particularly L-isoleucine, as bridging molecules between a silicon alkoxide and a metal acetate to form sol-gel precursors in a single reaction vessel. These precursors were then dissolved in tetrahydrofuran in aluminum dishes, and water was added to start hydrolysis and condensation. The resulting M-C-SiO_2 (M = metal) nanocomposite film structures had controllable porosities (from 10 nm to 500 nm in diameter) and metal contents, with one Pd-based nanocomposite having a connected metal volume fraction of 36 vol%, yielding the high electrical conductivity values. The researchers said they have formed M-C-SiO_2 nanocomposites with most metals in the periodic table using this process, and they expect that at least some of the less expensive metals will yield conductivities similar to that of palladium.

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