Tape recording patents inspire chemists to invent new Fischer-Tropsch catalytist

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Inspired by patents from the 1960's audio cassette recording industry, UvA chemists now developed a new Fischer-Tropsch catalyst. It can be used for the making of synthetic fuels from natural gas and biomass. This week the research on the new nanocobalt-ironoxide catalyst was published as a VIP article in *Angewandte Chemie*. The catalyst was patented by the Total S.A. oil and gas company.

Roberto Calderone, Raveendran Shiju and Gadi Rothenberg from the Heterogeneous Catalysis and Sustainable Chemistry group (Van 't Hoff Institute for Molecular Sciences) succeeded in growing nanometer-thin cobalt shells on iron oxide particles. These new materials are excellent Fischer-Tropsch (F-T) catalysts, giving good diesel fractions.

The Fischer-Tropsch process is used for producing fuels from synthesis

gas, which in turn is made from natural gas, biomass or coal. The large reserves of shale gas and natural gas currently changing the world energy market have raised interest in F-T technology. But there is a catch: F-T reactors are huge, and typically use hundreds of tons of catalyst.

Low cost, high performance

Cobalt-based catalysts are the optimal choice for synthesizing middle distillate fuels such as diesel and kerosene with F-T technology. But cobalt is also expensive. In 2009 the Total Gaz & Power company contacted Rothenberg's group to develop a new F-T catalyst together. The UvA researchers took up the challenge to design a cheaper catalyst that can be prepared on a very large scale, yet performs at least as well as pure cobalt.

The chemical aspects of their ambition were daunting. Gaining an economic advantage requires engineering of the particles at single-nanometer resolution, yet in a manner that can be scaled up to multi-ton scale. This rules out all chemical procedures that require high sophistication, extreme temperatures, or expensive chemicals.

Inspired by audio tape

The UvA team sought to meet these restraints with the so-called surface nucleation of a cobalt phase onto iron oxide colloids. They were inspired by the method that companies such as TDK used in the 1960s for producing magnetic tapes for audio cassettes. The standard recording materials in these cassettes were polymer-based tapes containing cigar-shaped cobalt-doped iron oxide particles.

After two years of hard work they achieved a cheap, reliable, efficient and, most importantly, scalable method for synthesizing spherical core-

shell catalyst particles. The particles have an average diameter of 10 nanometer (nm) and consist of a 8 nm magnetite (iron oxide) core with a cobalt oxide shell of only 1 nm. The new catalysts were then tested in collaboration with research groups of Andreas Jess in Bayreuth and Andrei Khodakov in Lille. They proved to be excellent Fischer-Tropsch catalysts, giving good diesel fractions.

Ideas and innovation

Rothenberg is proud of his team: "As an academic group, we cannot compete with industrial research teams on facilities, but we can compete with them on ideas and innovation".

He gives credit to his co-worker Roberto Calderone, who persistently pursued the idea of particle synthesis and coating based on the audio cassettes approach.

Rothenberg: "Being a chemist, I love the idea of making something so accurate (the cobalt shells are only a few atoms thick) yet using a procedure that any high-school student can repeat".

The new catalysts and the method for their preparation were patented by Total S.A., naming the UvA researchers as co-inventors. The research has just been published online as a VIP communication in the top-tier journal Angewandte Chemie and will be featured on the printed issue cover.

More information: De novo design of nanostructured iron-cobalt Fischer-Tropsch catalysts. V.R. Calderone, N.R. Shiju, D. Curulla Ferré, S. Chambrey, A. Khodakov, A. Rose, J. Thiessen, A. Jess and G. Rothenberg, Angew. Chem. Int. Ed., 2013, EarlyView. DOI: 10.1002/anie.201209799

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