Coal-to-diesel breakthrough could drastically cut oil imports

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Professor Alan Goldman and his Rutgers team in collaboration with researchers at the University of North Carolina at Chapel Hill have developed a way to convert carbon sources, such as coal to diesel fuel. This important advance could significantly cut America's dependence on foreign oil – what President Bush called "an addiction" in his 2006 State of the Union address. According to the U.S. Department of Energy, our 286 billion tons of coal in the ground translate into energy reserves 40 times those of oil.

Goldman explained that the breakthrough technology employs a pair of catalytic chemical reactions that operate in tandem, one of which captured the 2005 Nobel Prize in Chemistry. This dynamic chemical duo revamps the Fischer-Tropsch (FT) process for generating synthetic petroleum substitutes, invented in 1920 but never developed to the point of becoming commercially viable for coal conversion.

The FT process recently gained national attention through the efforts of Brian Schweitzer, governor of coal-rich Montana, who has been publicly extolling the potential of Fischer-Tropsch. The Goldman group's innovations eliminate shortcomings in the process that can finally make it a workable solution to dwindling domestic oil reserves.

"The key to energy independence in the next five decades is Fischer-Tropsch chemistry, amended and enhanced," said Goldman, a professor in the department of chemistry and chemical biology at Rutgers, The State University of New Jersey. "The study of catalysts, the little

molecular machines that control chemical reactions, is my field. With our new catalysts, one can generate productive, clean burning fuels with Fischer-Tropsch, economically and at unsurpassed levels of efficiency."

This discovery is reported in the April 14 issue of the journal *Science* by Goldman and his colleagues. The work grew out of a National Science Foundation-funded research consortium, the Center for the Activation and Transformation of Strong Bonds, based at the University of Washington.

Fischer-Tropsch yields a wide distribution of molecular weight hydrocarbon products but without any way to control the desired mix. The molecular weight is the weight of a molecule of a substance, or the sum of the weights of all atoms in the molecule. The low-weight and the high-weight Fischer-Tropsch products are useful – the light as gas and the medium-heavy as diesel fuel, Goldman explained.

"The problem – the greatest inefficiency of the process – is that you also wind up with a substantial quantity of medium-weight products that are not useful and you are stuck with them," Goldman said. "What we are now able to do with our new catalysts is something no one else has done before. We take all these undesirable medium-weight substances and convert them to the useful higher- and lower-weight products."

Technically, this is accomplished by a catalyst that removes hydrogen from the molecules. This converts the hydrocarbons to olefins, products with double bonds which are necessary for the creation of the desirable, useful end-products. The beauty of the new process is that it is highly selective in which hydrogen atoms it removes from the hydrocarbons, channeling the reactions to produce specific, useful products.

The researchers combined this process with the action of a second catalyst, one which promotes olefin metathesis, for which the 2005

Nobel Prize was awarded. Metathesis means "to change places" and, here, the double-bonding atom groups change places with one another. Through this reaction, the second catalyst rearranges the molecular weight distribution of the olefins. The first catalyst then replaces the hydrogen atoms onto the new rearranged olefins; this returns the olefins back to their original hydrocarbon form, but now with a new, more desirable weight distribution.

Source: Rutgers, the State University of New Jersey