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Faculty Spotlight: Semih Eser

In his days as a Ph.D. student at Penn State, Professor of Energy and Environmental Engineering Semih Eser took to snacking on red fruits he would pluck off of the trees on the east side of University Park campus.

Although rumored to be poisonous, Eser had known about Cornelian cherries from a young age, because he grew up with them in Turkey. Not only did he consider the tart fruits to be great for nibbling, but he also developed them into research, making activated carbons out of the cherry stones for purifying water.

?This is nature?s wonder...If you can open these up, create porosity on the surface that runs all the way across, then these are very nice granules that you can use for cleaning water,? says Eser, who published a paper detailing how carbon can be activated in one step by sending steam through the fruit stone as it is heated.

?I was actually making the feedstock while eating the cherries and keeping these and washing them,? he says, with a laugh.

A research affiliate of the Penn State Energy Institute, Eser has since continued investigating desirable carbons as well as undesirable carbons.

?Carbon is an incredible element,? he says. ?You can have graphite and diamond?two extremes of the spectrum.?

Eser received his bachelors and masters degrees in chemical engineering at the Middle East Technical University in Ankara, Turkey. He moved to the United States in 1981 and earned his Ph.D. in fuel science from Penn State in 1987. He served as head of the department of energy and environmental engineering for five years.

Problem Carbons

In the area of undesirable carbons, Eser and his research team are making advancements to address the problem of carbon deposition from jet fuel engine components.

When jet fuels are heated to elevated temperatures and come into contact with the metal surfaces of the engine, a chemical reaction occurs that produces carbon deposits or ***filamentous carbon***. The metal surfaces of the engine components are corroded and long carbon fibers start to form.

?It?s almost like grass growing within the internal surfaces of a pipe and that?s dangerous,? he says. ?Not only is it providing a physical block, but it acts like a catalyst surface that starts reacting with fuel and then we have a secondary growth on these filaments or fibers.?

As the fibers of carbon thicken, the jet?s fuel lines are at risk of being blocked and the system could potentially fail.

One unique contribution that Eser?s research team has made to this area is a technique called ***temperature program oxidation***, which has led them to prove that different kinds of carbons are depositing on the surface. Ultimately, the technique characterizes what kinds of deposits are taking place by looking at how readily carbonaceous deposits will burn and by monitoring the evolution of the carbon dioxide.

?What we have also found in our work is that...all jet fuel samples, whether it is a civilian or military, JET A or JP8, contain sulfur in various concentrations,? he says. ?Sulfur in essence acts as an initiator of surface degradation where you have fuel interacting with the surface.?

Therefore, it?s important to find metals or design alloys that do not readily react with sulfur. Eser and his research group have tested and found one super alloy called Inconel 718 to perform very well due to stabilizing elements found in the composition, such as aluminum and titanium and niobium.

In addition, there are techniques to reduce deposition that relate to the fuels, including: stabilizing the fuel with additives, altering the engine conditions so temperature of the fuel stays lower, and developing different fuel formulas.

Coatings or thin films less than a micron thick have also been developed to prevent the fuel from coming into contact with the active surface metals, and Eser says that an invention disclosure provisional for one such coating is in the works.

Desirable Carbons

While some types of carbons are cause for concern, Eser is also looking at desirable carbons and how to maximize the benefits of their applications. One such application is making needle coke to develop graphite electrodes, which serve as good heat conductors in melting down scrap iron and steel.

Iron and steel are among the most widely recycled materials the world and it?s much more inexpensive to reuse steel and iron rather than to mine new iron ore. Scraps are commonly melted in an electric arc furnace.

But according to Eser, making the electrodes is no easy task. Baking and graphitizing them is an incredibly involved process and can take weeks, sometimes months.

?The key research I?ve been involved in is to make them last as long as possible,? he says. ?All they?re doing there is conducting electricity, but of course since the temperatures are so high, you tend to lose part of it and then you need to replace the electrodes.?

To increase the strength and efficiency of the electrodes, Eser is assessing the chemistry of a specific phase in the electrode production process called ***carbonaceous mesophase.*** Another obstacle is finding ways to successfully remove sulfur before needle coke is made, since sulfur can damage electrodes as they bake.

Two publications have been submitted by Eser and his colleague, G. Wang, to Energy and Fuels and are currently under review. The first focuses on determining the molecular composition and how it effects the formation of the liquid crystalline phase, or carbonaceous mesophase. The second focuses on the effect of removing sulfur on mesophase development during carbonization.

Eventually, Eser says he hopes to ?retool his research activity to more effectively address the critical urgency of dramatic increases in the efficiency of fossil fuel use and developing new means of renewable energy conversion.? For now, he continues to investigate the desirable and undesirable varieties of this fascinating element?one that plays both a hero and a villain.

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