Gasification may convert mesquite and juniper wood to a usable bioenergy

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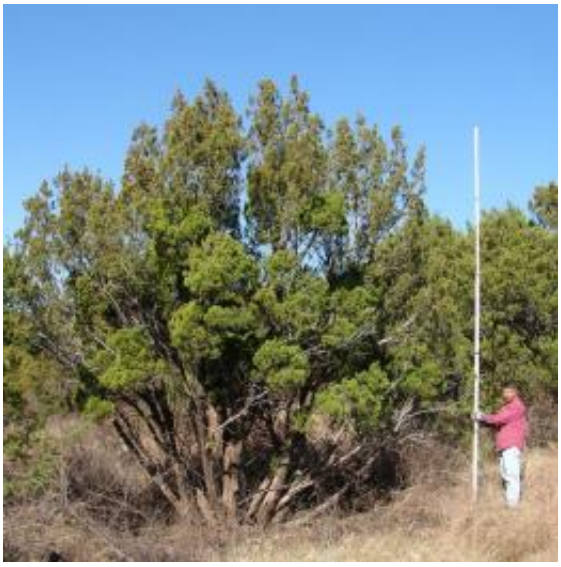

Dr. Mustafa Mirik, Texas AgriLife Research associate scientist at Vernon, takes a measurement of a redberry juniper tree before it is harvested for the study. Credit: Dr. Jim Ansley

Biomass gasification is being considered as a possible technology for converting at least 10 million acres of Texas brush into biofuel, according to Dr. Jim Ansley, Texas AgriLife Research rangeland ecologist in Vernon.

A study using an adiabatic bed gasifier to convert mesquite and redberry juniper species found in the Southern Great Plains into usable bioenergy

gases was conducted by Ansley and Dr. Kalyan Annamalai, Paul Pepper Professor of Mechanical Engineering and Coal and Biomass Energy Laboratory, Texas Engineering Experiment Station at Texas A&M University in College Station.

The team also included graduate students Wei Chen, Dustin Eseltine and Siva Thanapal in College Station, and Dr. Mustafa Mirik, AgriLife Research associate scientist at Vernon.

The first published paper on this study, which appeared at www.elsevier.com/locate/energy with Chen as lead author, determined the heating value of mesquite and juniper, as well as the effects of wood chip particle size and moisture content on gas composition and yields, Ansley said.

The study found some of the basic thermal properties of these solid fuels, including chemical composition and heat values, and various heating factors affected syngas yields, he said. Syngas, a mixture of carbon monoxide, ethane and hydrogen, can be used as a substitute for natural gas. A solid by-product of the conversion process, tar, may also be used for fuel or other chemical products.

Dr. Mustafa Mirik, Texas AgriLife Research associate scientist at Vernon, and former technician Gerral Schulz put mesquite branches through the chipper before sending them to College Station for gasification and testing. Credit: Texas

AgriLife Research photo

With limitations for growing bioenergy crops on land normally used for growing food, Ansley is looking to the vast supply of unwanted woody plants on rangelands as a possible energy source. The down side would be increased transportation costs, because of the trees' lower biomass density. One option might be to develop small-scale, localized gasification facilities to convert the trees into usable bioenergy.

"Right now, they are perceived as noxious plants that are detrimental to rangeland ecosystems," he said. "Their removal and use as a bioenergy feedstock would improve ecosystem quality as well as services from these lands, such as increased income from livestock grazing."

With no available data regarding gasification of mesquite and juniper, Ansley said his team's objective was to determine the heating value of the two woods and obtain gasification performance data.

Mesquite and juniper can achieve standing biomass of 20 dry tons per acre, he said. Moisture content of these species is much lower than other woody feedstocks and this contributes to greater heating value and lower costs for drying the feedstock.

Mesquite and juniper samples were harvested from native rangeland areas near Vernon. The trees were multi-trunked, 10-12 feet tall with diameters ranging from 2-8 inches. Tree ring counts indicated that above-ground portions of these trees were 15-35 years old.

Basal stems and branches were passed through a wood chipper, he said. The chipped material was then passed through a motorized sieve system to separate into different particle sizes. Wood chips were then stored in

cellulose bags and transferred to College Station for gasification trials.

Mesquite stems were chipped and gathered in collection bins during the study. Credit: Texas AgriLife Research photo by Dr. Jim Ansley

The team's article is the first to report the heating content and syngases derived from these woods, as well as some potential yields and composition from gasification, Ansley said.

The heating value of redberry juniper wood was slightly higher than mesquite – 8,849 Btu per pound compared to 8,653 Btu per pound, Ansley said. Both values are equivalent to medium grade subbituminous coal.

He said mesquite and juniper woods are better quality fuel than cattle manure biomass which has lower heating value, 5,520 Btu per pound, and much higher ash content, 14-45 percent compared to 1-2 percent in the wood.

The power plants typically prefer low nitrogen fuels so the U.S. Environmental Protection Agency-regulated pollutant nitrogen oxides can be minimized. As opposed to coal, mesquite and juniper contain very low amounts of nitrogen, about one-third to one-half of coal.

Nitrogen content was slightly higher in mesquite than juniper, because mesquite is a legume that fixes its own nitrogen, Ansley said.

Wood chips of different sizes were combusted within a steel column that produced a range of temperatures from 400-2000 degrees. This caused various stages of wood decomposition and syngas yield, he said.

Syngas yield was comprised of nitrogen gas, carbon monoxide, carbon dioxide, hydrogen gas, oxygen, methane and ethane. Percentage gas composition varied between the wood types, but juniper had a slightly higher percentage of carbon monoxide and methane, while mesquite had higher percentages of nitrogen, carbon dioxide and ethane.

The heating value of syngases produced from these woods was slightly higher in juniper than mesquite, 1,482 Btu per pound compared to 1,275 Btu per pound, Ansley said. When nitrogen was removed from the gasifier, the heating value of syngases from both wood types more than doubled to about 3,575 Btu per pound and 3,261 Btu per pound for juniper and mesquite, respectively.

Compared to pure methane, which served as a surrogate for natural gas, syngases from these woods reached almost 100-150 Btu per standard cubic foot, which is about 10-15 percent of the heating value of methane, he said. When nitrogen was removed, syngas heating value increased to 27 percent and 25.8 percent of methane heating value for juniper and mesquite, respectively.

Both wood types generated high-quality gas, but the juniper gas quality was slightly better than mesquite primarily due to lower nitrogen content and higher heating value, Ansley said.

Provided by Texas A&M University

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