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Lignin-Derived Research Octane Number and Heating Value Improvers for Gasoline

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INTRODUCTION
After cellulose, lignin, an integral part of plant cell walls, is the most widely available organic compound in the world. Lignin, derived from the Latin word for wood, lignum, is a complex polymer of aromatic oxygenates (e.g. p-coumaryl alcohol, coniferyl alcohol, and sinapyl alcohol). A representative depiction of a lignin molecular structure is presented in Figure 1.

![Figure 1. Typical lignin molecular structure](image)

A waste stream in the paper plants and, more recently, in cellulosic ethanol plants, lignin is primarily burnt for process heat. Burning complex biological molecules like lignin to generate relatively low-value process heat, while economically viable, should be viewed as a latent cost. This is because its unique aromatic structure is the only large-scale and sustainable feedstock for producing bio-aromatics, which in turn serve as feedstocks for such daily products as nylon stockings and aspirin. Inevitably, there will be less useful fractions of lignin that cannot be converted into high-value chemicals. These lower value side streams could potentially be used as biofuels. In this abstract, a preliminary investigation will be presented into the use of lignin-derived mono-aromatic oxygenates as octane and energy improvers for fossil gasoline. This paper will not discuss the thermo-catalytic production process currently under development which can depolymerise lignin into compounds like those discussed later on in this abstract.

METHODOLOGY
Arguably, two of the most important fuel properties for gasoline applications are the research octane number (RON) and (volumetric higher) heating value (HHV). The energy density and RON were measured as according to ASTM D 240 and ASTM D2699, respectively at Intertek in Rotterdam, the Netherlands. In order to investigate how mono-aromatic oxygenates, like those found in lignin, perform as fuels, a total of 7 aromatics oxygenates were tested and benchmarked against ethanol and conventional EN224 gasoline. In compliance with industry standards, the RON and HHV were measured at Intertek (Rotterdam) for each blend of 90 vol.-% gasoline and 10 vol.-% aromatic oxygenate or ethanol.
RESULTS AND DISCUSSION

In Figure 2, the RON and HHV (expressed in MJ/litre) of the investigated 90/10 blends are presented relative to neat gasoline. Ethanol is taken as a benchmark oxygenate.

![Graph showing RON and HHV values for different compounds.]

**Figure 2.** Aromatic oxygenates

With the exception of guaiacol, which has a relatively high oxygen concentration (i.e., two instead of one functional oxygen groups attached to the aromatic ring), all investigated aromatic oxygenates have a positive effect on both the RON and HHV. Conversely, the benchmark oxygenate, ethanol, while having a positive effect on the RON, has a detrimental impact on the HHV. Accordingly, utilization of lignin monomers as drop-in renewable compounds for gasoline appears to be quite promising as their higher RON and HHV promise a better power performance and fuel economy, respectively.

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