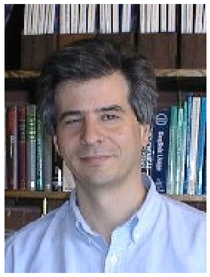

Pyrolysis Research at Advanced Fuel Research, Inc. (AFR)

By Michael A. Serio, AFR, East Hartford, CT USA

AFR has been involved for several years in R&D on the pyrolysis-based conversion of biomass into fuels, chemicals and materials. Much of this work has been sponsored by the U.S. Government, in particular the Department of Energy (DOE), the National Science Foundation (NSF), the Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA) and the National Aeronautics and Space Administration (NASA). In addition, significant biomass R&D work has been carried out for private companies and institutions.

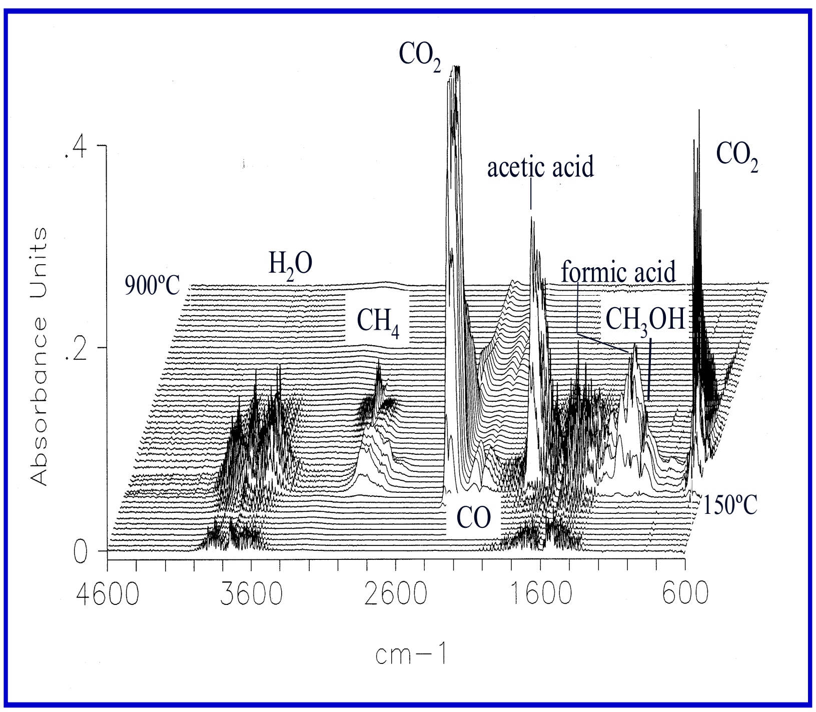

Figure 1: Sequential FT-IR spectra of xylan sample from TG-FTIR analysis at 30 °C/min.

A primary investigative tool is a thermogravimetric analyzer equipped with FT-IR analysis of evolved gases (TG-FTIR). While TG-FTIR systems are available from several manufacturers, the system used at AFR was developed in-house with the collaboration of Bomem, Inc., an FT-IR spectrometer company. It is designed to permit analysis of the heavy tars (liquids) that form from the pyrolysis of biomass materials, in addition to the light gases [1]. A stack plot of FT-IR spectra collected from pyrolysis of a sample of xylan in the TG-FTIR apparatus is shown in Figure 1.

Figure 2 shows a comparison of quantitative evolution rate data for major pyrolysis species from the TG-FTIR for samples of cellulose, xylan and an organsolv lignin. These types of data are usually collected at multiple heating rates and used to build pyrolysis models based on the methodology used in AFR's Functional-Group. Depolymerization, Vaporization, Crosslinking (FG-DVC) model [2]. The data in Figure 2 clearly show the differences in the pyrolysis behavior of the different feedstocks. For typical biomass samples, quantitative data are routinely obtained on nearly 20 volatile species, including tars, H_2O, CO,CO_2, COS, SO_2, CH_4, C_2H_4, HCN, NH_3, acetic acid, acetaldehyde, formic acid, formaldehyde, methanol, phenol, acetone, and levoglucosan.

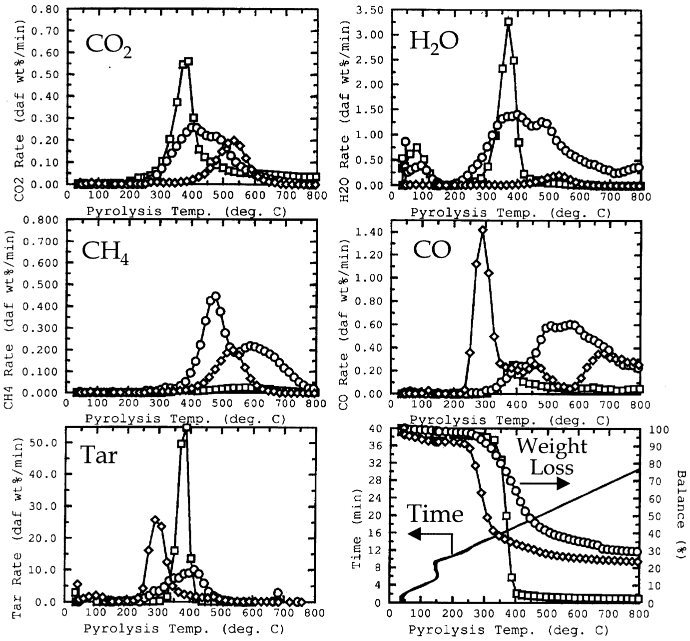

Figure 2: Comparison of TG-FTIR pyrolysis data for cellulose (squares), hemicellulose (xylan, diamonds), and ALC lignin (circles) at 30 °C/min.

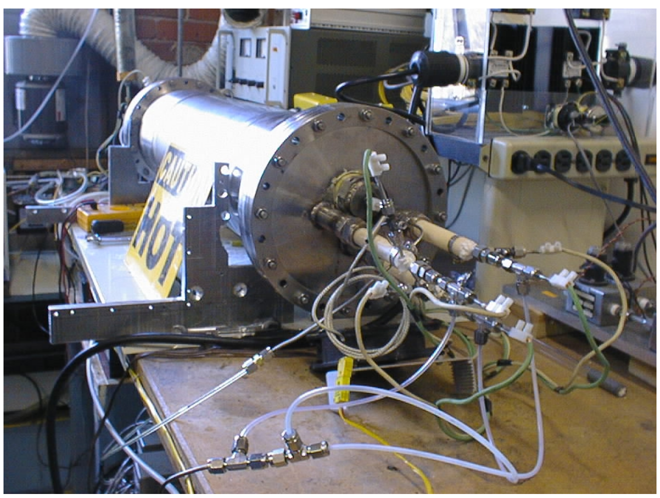

Figure 3: Picture of inlet side of NASA prototype pyrolyzer.

Many different types of biomass materials and waste products have been studied. These include the pyrolysis of lignin to produce chemicals [3], pyrolysis of waste tires to produce activated carbon and carbon black [4], and pyrolysis of plant biomass materials to produce fuel gases, chemicals and materials (activated carbon) [2]. A current NASA sponsored study is developing a prototype pyrolyzer for recycling of mixed solid waste streams in space [5]. The equipment is shown in Figure 3.

AFR is constantly expanding its biomass pyrolysis database with the purpose of providing kinetic and composition inputs to the biomass pyrolysis model. The kinetic data collected at low heating rates, where product resolution and quantification are relatively easy, is used in the model to obtain predictions for high heating rate pyrolysis.

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