VALUE-ADDED PRODUCTS FROM THE ENLARGED WOMBAT REACTOR.

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The WOMBAT process has been utilized to degrade scrap tires into several materials -- a black powder, a mat which has a shape similar to that of the original tire, fibers, steel, and highly discolored nitric acid.[1] Each of these materials is produced in large quantities, and the utilization of each is necessary to produce and environmentally acceptable and an economically useful bottom line for this method. The WOMBAT process has the potential for high through put of tires, and the tires do not require any pre-treatment. After the steel belts have been cleaved from the styrene-butadiene (SBR) matrix of the tire, the belts may be recovered from the reactor with minimal surface corrosion. Both the black powder and the SBR mats may be separated from the fibers and from each other. A schematic of the new and enlarged WOMBAT reactor is presented in Figure 1.

The chemistry of the WOMBAT process may be traced, to some extent, using x-ray fluorescence (XRF) spectrometry. The XRF experiment measures the secondary Xrays emitted by a sample using a separation technique based either on the differences in energies of the emitted Xrays or their differences in wavelengths.[2] For these experiments, a rhodium x-ray tube (operating at 35 kV and 30 ma) and a graphite monochromator were used. Shown in Figure 2 is the WDXRF spectrum of a 1" x 1" x ¼" piece of a tire. This spectrum contains several orders of the K_β and K_α wavelengths emitted by zinc (normally present in the 2-3% range in tires) which occur at λ = 1.30 Å and λ = 1.44 Å, respectively. Also noted is the K_α wavelength for sulfur (normally present in the 1.0-2.0% range in tires) at 5.37 Å.
Shown in Figure 3 is the WDXRF spectrum of the black powder recovered from the WOMBAT process. There is no K_β and K_α peaks indicative of zinc in this spectrum, indicating that the abundance of zinc in the black powder < the lower limit of detection for zinc in this sample. However, the sulfur K_α peak, at λ = 5.37 Å, is clearly discernible in this WDXRF spectrum, indicating that sulfur is retained in this powder.

In previous experiments, it has been shown that the black powder has an energy content ca. 30% higher than the typical bituminous coal and produces <1% high temperature ash. It may be co-combusted with lower energy fuels such as lignite and/or sawdust. However, because the powder retains sulfur, it may be used in processes that require vulcanized materials. Furthermore, because of its high surface area/mass ratio, the black powder also has potential for sequestering metal ions. Shown in Figure 4 is the WDXRF spectra of (a) the black powder and (b) the black powder after it had been dispersed into a solution containing copper(II) nitrate and then recovered. The latter spectrum contains large K_β and K_α x-ray peaks (at λ = 1.39 Å and λ = 1.54 Å, respectively) due to copper. Subsequent experiments have shown that most of the copper(II) sequestered onto the black powder may be removed from the powder by washing with water.

Having shown that the black WOMBAT powder will sequester copper(II) from an aqueous solution, we are investigating the sequestration properties of the powder towards other metal ions present in water, soil, and air and are also investigating its capabilities for sequestering organic moieties.

The SBR matrix, the other high carbon material recovered from the degradation of the tire, may be cleanly separated from the tire's steel belts and fibers. This SBR matrix, whose WDXRF spectrum is presented in Figure 5, contains considerable amounts of zinc, iron, and sulfur -- as evidenced by the characteristic peaks for these elements in the resulting WDXRF spectrum. This matrix has a high fuel value and produces only 3-4% HTA. In addition, as shown in the x-ray diffractogram presented in Figure 6, the HTA is principally ZnO.

The discolored WOMBAT liquid, which has a considerably reduced oxidizing powder, may be converted to inorganic nitrate salts such as potassium nitrate or ammonium nitrate. The x-ray diffractogram of the chemical product produced when the used WOMBAT liquid is reacted with potassium hydroxide is presented in Figure 7.

REFERENCES.

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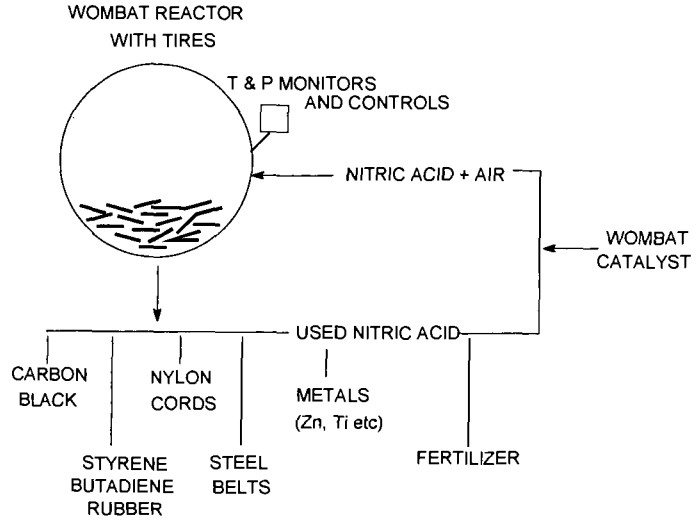

Figure 1. Schematic of new and enlarged WOMBAT reactor.

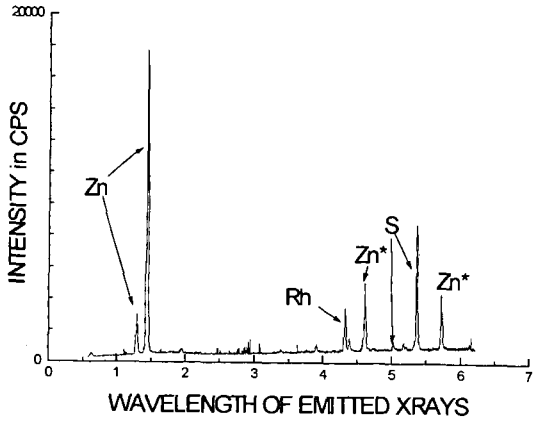

Figure 2. WDXRF spectrum of a 1" x 1" x ¼" piece of scrap tire.

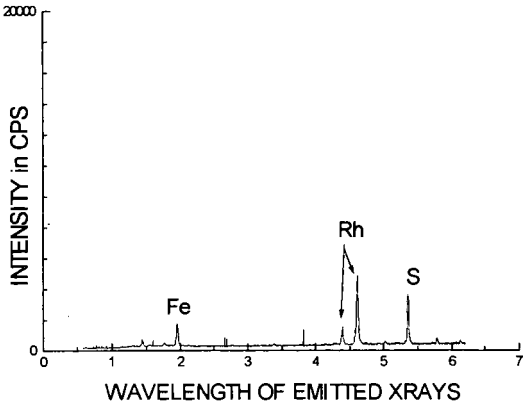

Figure 3. WDXRF spectrum of the black powder recovered from the WOMBAT reactor.

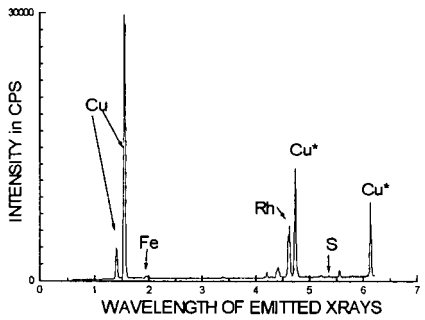

Figure 4. WDXRF spectra of the black powder prior to (circles) and after (squares) treatment with an aqueous solution containing copper(II).

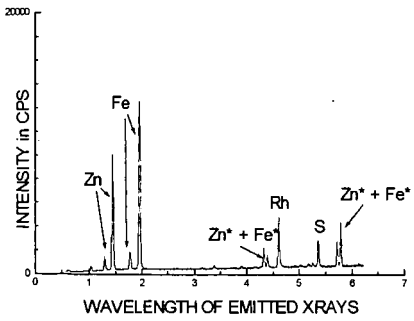

Figure 5. WDXRF spectrum of the SBR matrix recovered from the WOMBAT reactor.

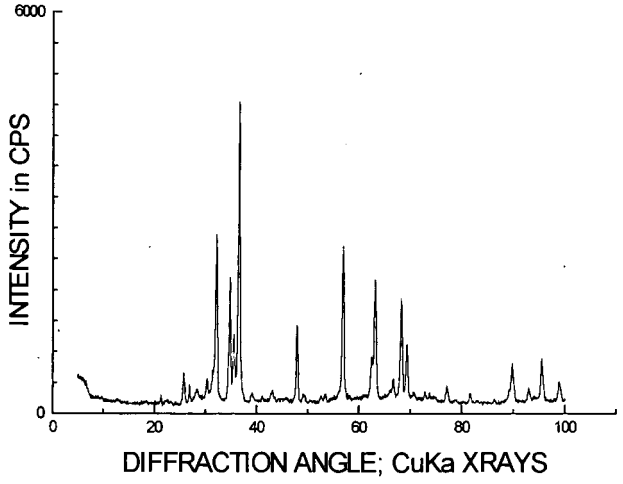

Figure 6. X-ray diffractogram of the HTA ash produced by combusting the SBR matrix.

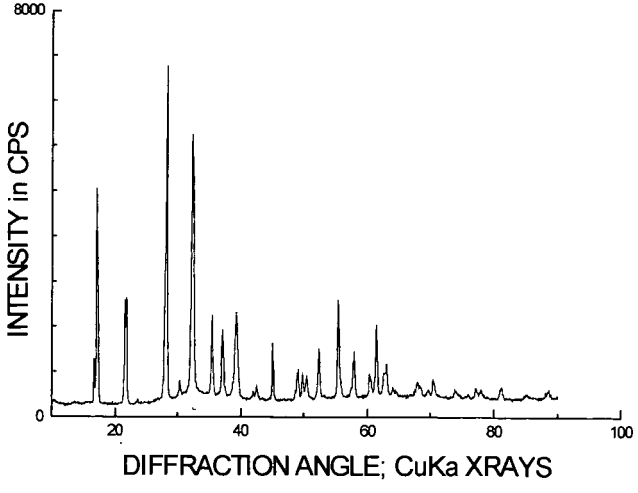

Figure 7. X-ray diffractogram of the solid produced from evaporating the mixture of "used" WOMBAT fluid and potassium hydroxide. XRD matches JCPDF 8-452, form IV ammonium nitrate.