Treatment of Bauxite Tailings Into Useful Products

Paige Kleinow, James Kenney, Jessica Montgomery, Jared Pecore, and Gerard T. Canea*
Department of Chemical Engineering, Michigan Technological University, Houghton, Michigan 49931

*Corresponding Author

Abstract
Bauxite is a dangerous by-product from producing aluminum. This material is environmentally hazardous by creating habitat destruction of rain forests, evidence of soil erosion with growing vegetation, water pollution and harmful effects to humans. To solve these issues, polymer research is being done to create useful products from bauxite for consumers.

Introduction
Bauxite is a by-product in the production of aluminum [1]. This material consists of four components; Aluminum Oxide (Al₂O₃), Silicon Dioxide (SiO₂), Iron (III) Oxide (Fe₂O₃) and Titanium Oxide TiO₂. These components vary in compositions and are highly basic with a pH ranging from 10 to 13. This makes the tailings material, called red mud, very hazardous.

Surface treatment to neutralize the red mud to pH = 7 - 8 is done using the neutralized and un-neutralized Vinyl Acetate/Vinyl Alcohol/Acrylic Acid block copolymer made via the FRRPP process [2].

In the presence of a caustic environment, the vinyl acetate segments are catalyzed into vinyl alcohol segments with the release of acetic acid. The acetic acid, in turn, neutralizes the red mud. Particulates. After drying, the polymer deposits on red mud surfaces to form a binder or coupling agent.

Experimental Method, Treated Particulate Analyses, and Product Results
A red mud sample was taken and neutralized to a pH of 7 with the treatment copolymer, which can be as low as 3.5 wt % in the copolymer-red mud solid. Scanning electron microscopy (SEM) studies show that the treatment polymer has fully coated the red mud particulate surfaces and the absence of lead, heavy metals, and rare Earths through X-ray surface analysis. Several products have been created thus far. One is a consolidated cylinder of treated red mud material with 3.5 wt % copolymer. Others are combination of the treated red mud with precursor to polyurethane and polyacrylic paints. Painted wood surfaces with more than 50 wt % treated red mud in the solid coatings (flat finishes) exhibited excellent adhesion onto wood surfaces, using the crosscut Scotch tape™ tester method. Polyurethane paint onto an Aluminum surface exhibited very good adhesion, and can be topcoated with polyurethane enamel for a glossy finish. The third product type created were compositions of Rockite™ and Quickrete™ with treated red mud at 25 wt % treated red mud in starting solid mixture. These were compared to the pure material, and were determined to be a little more brittle than cement products without treated red mud.

Aquatic Toxicity Results
Microtox™ testing was performed on samples of untreated and treated red mud in water at 35°C. This testing consisted of adding micro-bacteria to the samples and reading the effectiveness of the bacteria. This shows the relationship between percent effectiveness and concentration for treated red mud, which indicated 50% Effectiveness (EC50 or concentration of toxic substances in the water that will drop microbial population by 50%) to be in the order of 15 times more than that of untreated red mud. This means that the treated red mud is 15 times less toxic in water than treated red mud. The numbers also seem to indicate that water from treated red mud is much less toxic that sand from salty seawater.

Future
Testing will continue for combinations of treated red mud with other paint formulations, to involve other types and composition ratios. Testing will continue with Rockite™ and Quickrete™ at different ratios with red mud. For the future of this research, incorporation of treated red mud with other building materials and recycled polymers will be investigated for possible consumer products.

References and Acknowledgments

The authors acknowledge the US Environmental Protection Agency (EPA) P3 Program for funding this project, Rio Tinto Alcan (Montreal) for supplying the red mud samples, and the MTU Center for Environmentally Benign Functional Materials (CEBFM).