UTILIZATION OF REACTIVATED CARBON IN STABILIZATION OF ORGANICS IN SOLIDIFICATION / STABILIZATION PROCESSES FOR HAZARDOUS WASTE TREATMENT

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Introduction

Cement-based solidification/stabilization (S/S) has been recognized by USEPA as an "acceptable" technology for hazardous solid waste treatment. This process, which immobilizes hazardous contaminants in a solidified monolith, has been successful in stabilizing heavy metals and some organics. Most hazardous organic materials, however, are poorly immobilized by S/S, and tend to leach out of the solidified waste to the ground. This occurs because organics do not, in general, react with cement, as metals do [1]. Therefore, S/S process has been modified in some cases by adding adsorptive materials to the cement, such as clays, metal oxides, and flyash, in order to immobilize organics [2]. In this study, the potential of adding reactivated carbon, a cost-effective adsorbent, for S/S of organics was studied.

Experimental

Ordinary Portland cement (OPC) was used to solidify synthetic batches of sand contaminated with hazardous organic compounds. ASTM standard procedure was followed (ASTM C192-88) in sample preparation. Calgon reactivated F400 carbon (PA, USA) was added in amounts ranging from 0.5 to 2% based on dry sand weight. The immobilization of a variety of organic compounds was tested. These include: phenol, aniline, chlorobenzene, MEK, naphthalene, and 2-chlorophenol, in high concentrations. The standard leaching tests applied are Toxicity Characteristic Leaching Procedure (TCLP) [3] and ANS 16.1. The effect of organics and reactivated carbon on hydration of cement was tested using FT-IR and FESEM. Homogeneity of carbon mixing into the cement matrix was tested using X-ray mapping. Aqueous phase adsorption tests were conducted using the bottle-point method to characterize the behavior of reactivated carbon under conditions similar to those in the S/S matrix.

Results and Discussion

Adsorption isotherms were measured on the reactivated carbon at different pH values and were compared to that for virgin F400 carbon. Figure 1 shows these isotherms for phenol at pH 7. It is observed that reactivated carbon has a high capacity, comparable to the virgin carbon. This was observed at all pH values. The kinetics of adsorption of phenol on carbon in carbon-sand slurry (1 and 2% carbon, by sand weight) was also studied. More than 95% of the initial phenol amount (5000 ppm) was found to be adsorbed on carbon within the first 15 minutes, as shown in Figure 2, indicating only a marginal retardation of adsorption due to the presence of sand.

TCLP and ANS 16.1 leaching tests were conducted on samples contaminated with organics, with and without adding the carbon. For all organics tested, leachability was significantly reduced by the addition of as low as 1% carbon. The exception was naphthalene, which has a very low solubility, for which cement was sufficient to prevent the leachability and not much improvement was observed by adding the carbon. Presented in Figure 3 are TCLP leaching data for phenol. The reduction in leachability is clearly observed, indicating an enhancement of the S/S process dut to the addition of carbon.

Finally, reactivated carbon was found to be homogeneously mixed into the cement matrix. Moreover, the addition of carbon was found to enhance the hydration of cement by adsorbing organics that retard the hydration. This was confirmed using FT-IR. Sample data for phenol are shown in Figure 4.

Conclusions

Reactivated carbon was found to be an efficient adsorbent of organics for hazardous solid waste treatment by the S/S process. In addition to significantly reducing the leachability of most organics studied from the solidified waste, the addition of carbon was found to enhance the cement hydration by removing organics that retard hydration. Implementing this process might lead to significant environmental advantages by reducing the leachability of hazardous materials. Additionally, it can result in a new market for spent activated carbon, and its consequent removal from the waste stream.

References

1. Vipulandan, C. Effect of clays and cement on the solidification/stabilization of phenol-contaminated soils. Waste Management, 1995; 15:399-406.

2. Cadwell, R. and Cote P. Investigation of solidification for the immobilization of trace organic contaminants. Haz. Waste & Haz. Materials, 1990; 7:273-282.
3. CFR, Part 268, Appendix I. Toxicity characteristic leaching procedure (TCLP), Federal Register, USA, 1988.

Acknowledgement

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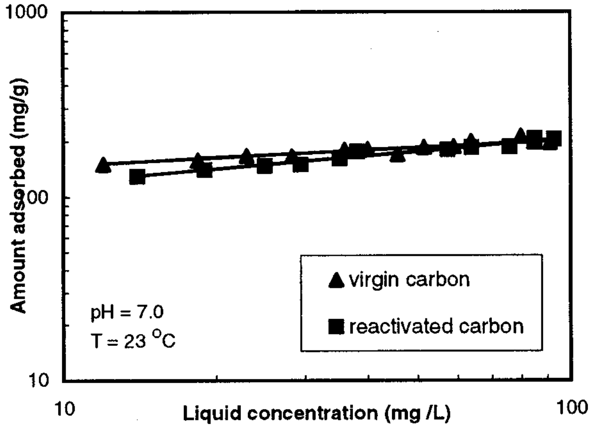

Fig. 1. Comparison of adsorption capacity of virgin and reactivated carbon for phenol

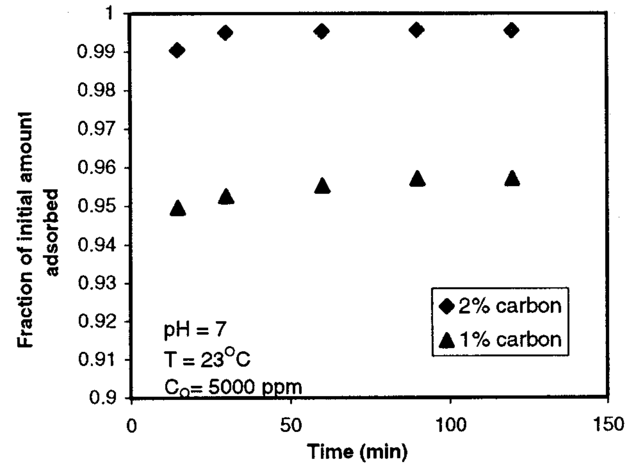

Figure 2. Adsorption rate of phenol on reactivetd carbon in carbon-sand mixture

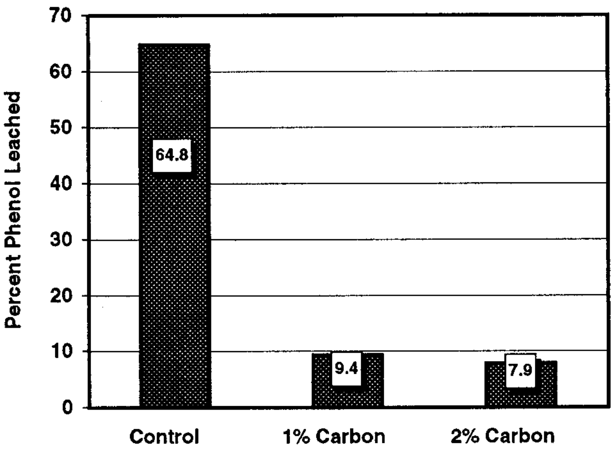

Figure 3. TCLP leachate analysis of phenol (1000 mg/L) for different reactivated carbon loadings

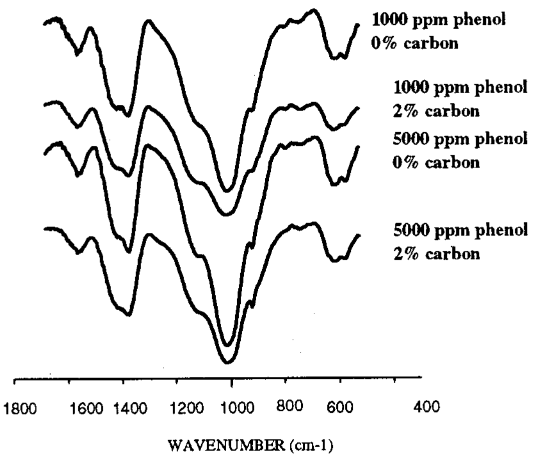

Figure 4. FT-IR spectra of cement loaded with phenol