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Leaching Behavior Of Oil In Cement-Based Solidified Oily Sludge

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ABSTRACT

Solidification of hazardous waste using Portland cement has been and is currently being used in solidification technology, but knowledge of the exact leaching behavior of contaminants is limited. In this study, the effects of parameters including time, temperature and the cement/sludge ratio on the diffusion behavior of oil after the solidification of oily sludge were investigated by using extraction and UV spectrophotometer. These experimental results indicated that the quantity of oil diffusion varies from 1.18 at 24 hours to 3.48 mg/L at 72 hours. The amplitude of oil diffusion within 72 hours is the most distinct and thereafter, the variation becomes slower. The diffusion quantity enhances from 2.01 to 2.77 mg/L with the increment of temperature under the range of 298~308K. The trend displays flat when the temperature is beyond 308K. The amount of oil diffusion reduces from 3.82 to 2.80 mg/L with the increasing of the cement/sludge ratio under the range of 1.0 ~1.8. The diffusion quantity reaches 2.69mg/L at 120 hours after adding reinforcing agent of melamine resin, which is lower than without reinforcing agent. The diffusion quantity could arrive at 5mg/L through 120 hours, which meets the demands requested by national first order dispatching in China.

KEYWORDS

Oily sludge;
Leaching behavior;
Solidification;
Oil.

INTRODUCTION

The solidification technology is commonly used as the final treatment step for treating hazardous wastes before they are land disposed[1-4]. It involves adding one or more solidifying agents to a waste to convert it into a monolithic solid with structural integrity. Through solidification, the waste is chemically stabilized and physically modified into a low permeability solid matrix. The leachability of the

waste is therefore reduced. The resulting product is also easier to handle and transport[1].

Among the various types of binders used for solidification, cement-based systems are the most commonly used systems because of their low cost and versatility[5-9]. Cement-based techniques use hydraulic cement as the major solidifying reagent. Solidification relies on the reaction of the cement with the aqueous phase of the waste or with the added water. Additives such as fly ash, blast furnace slag and sodium silicate are often used to replace part of the cement either to lower the cost or to improve product performance.

However, these progresses were designed to manage heavy metals in the waste, not organics. Organics are present to some degree in many predominantly inorganic waste materials, and their leaching can lead to serious public health or environmental problems. Studies involving the use of solidification processes for organic wastes have reported little successes in immobilizing the organics constituents. Consequently, there is a great need to develop effective and economic solidification systems that can reliably treat hazardous wastes containing organics. Very little information is available on the mechanisms involved with the release, or leaching, of organics from the stabilized waste. A better understanding of the leaching behavior of organics would enable us to predict their fate under "real-world" disposal conditions.

In this study, synthetic cement-based waste forms with oily sludge generated from the oil production and processing activities, were prepared and subjected to a toxicity characteristic leaching procedure (TCLP) to study the effect of parameters such as time, temperature, cement/sludge ratio and different additives on oil leaching.

EXPERIMENTAL

Materials

The oily sludge for this research was taken from shengli oil production plant. The additives used were cement, sand, clay, fly ash and lime and the accelerators used were sodium silicate, bentonite.

UV-Vis spectrophotometry (shimadzn, UV-160u) was used to determine the concentration of oil in the leachate.

Mixture preparation

The sludge was mixed with additives in different properties followed by the addition of water to form homogenous mixtures. The prepared mixtures were poured into standard moulds of size 111*111*111 mm. The solidified blocks were removed from moulds after 2 days and cured for 28 days under the wet condition to set.

Leaching tests of solidified samples

Leaching tests were carried out with each solidified sample by toxicity characteristic leaching procedure (TCLP). The TCLP leachate was analyzed for oil.

The leaching experiments were performed by soaking the blocks with pure water. The jars were then capped and tumbled end over end for 18 hours. After 18 hours, the leachate was decanted and measured for the contaminants of interest and also for calcicum. Special care was taken (because of the volatile organics in the waste) to ensure that the TCLP jar was air tightly and had a zero headspace to prevent any volatilization during the tumbling operation.

RESULTS AND DISCUSSION

The leaching behavior of oil from the solidification matrix appeared to depend on several factors. These include: liquid/solid (L/S) ratio, curing period, concentration, and presence of other organic constituents. These effects of parameters including time, temperature, cement/sludge ratio and additives are discussed in detail in the following paragraphs.

Effect of time

The leaching behavior as a function of time was plotted in figure 1. The quantity of oil diffusion displays an upward trend gradually with the dissipation of extraction time. The concentration of oil leaching increases from 1.18 at 24 hours to 3.48 mg/L at 72 hours. The amplitude of oil diffusion within 72 hours is the most distinct and thereafter, the variation becomes slower. This is mainly because the

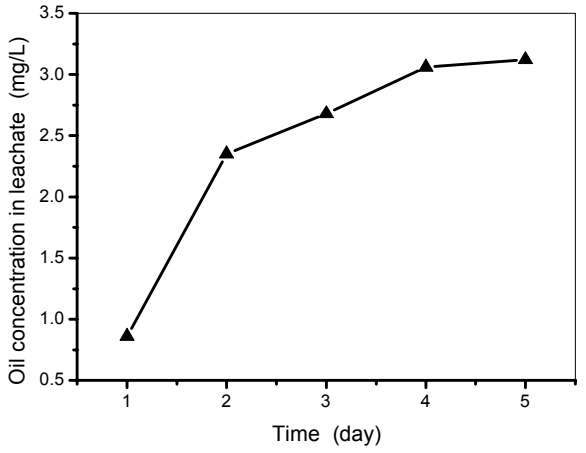

Figure 1: Relationship of the concentration of oil in leachate and time

amount of leaching is the function of the dissipated time. The longer the dissipated time for samples, the more is the amount of oil diffusion into the aqueous solution. As the diffusion process carried out at a specific degree, the gradient concentration of oil between the samples and aqueous solution becomes progressively smaller and the diffusion rate of oil into the aqueous bulk reduces. Consequently, the variation of oil diffusion exhibits flatter than previously.

Effect of temperature

Figure 2 showed the effect of temperature on leaching behavior of oil under the condition of the range of temperature 298-313K, cement/sludge ratio 1.6 and time 72 hours. The higher the temperature, the larger is the quantity of oil diffusion into the aqueous solution. The diffusion quantity enhances from 2.01 to 2.77 mg/L with the increment of temperature under the range of 298-308K. The trend displays flat when the temperature is beyond 308K.These influences are mainly due to the interaction of molecules under the range of 298-308K. As the temperature elevated, the movement of molecules becomes more rigorously, consequently, the quantity of diffusion is to be quickly. On the other hand, the viscosity of oil in the samples gets thinner as the result of elevated temperature. As the temperature lies between 308-313K, the change amplitude of diffusion rate and viscosity is smaller than

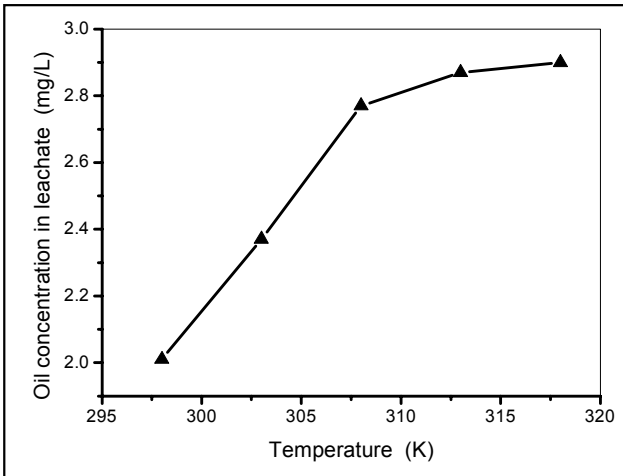

Figure 2: Effect of temperature on leaching of oil

the range of 298-308K, so that the amount of oil diffusion enhances more mild with temperature being beyond 308K.

Effect of cement/sludge ratio

The results of cement/sludge ratio on the leaching behavior are depicted in figure 3. As can be seen from figure 3, the larger the cement/sludge ratio, the smaller is the quantity of oil leaching. The quantity of oil diffusion reduced from 3.82 to 2.80 mg/L with the increasing of the cement/sludge ratio under the range of 1.0~1.8. A possibility for this result is that with the increase of content of cement, the microstructure of the hydration of cement becomes more tightly, which resulted in the permeability of oil in solidification blocks decreased dramatically.

Effect of additives

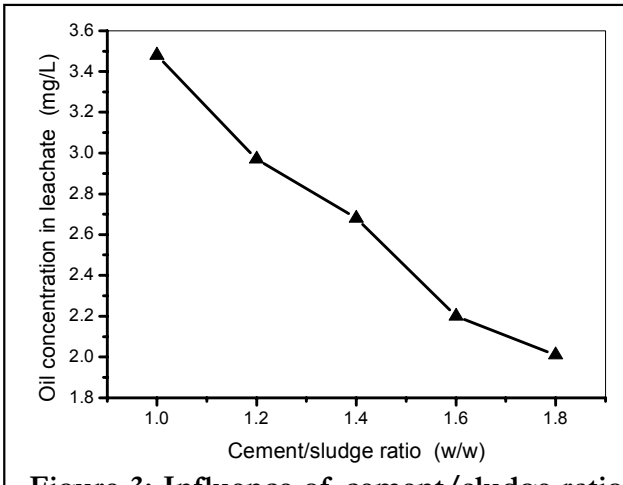

Figure 3: Influence of cement/sludge ratio on leaching of oil

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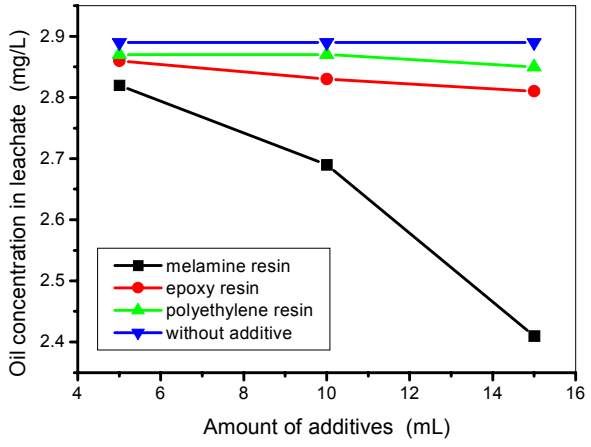

Figure 4: Effect of the enforcing agents on oil leaching

The effect of reinforcing agents on leaching behavior under the temperature of 298K, cement/sludge ratio of 1.80, and the time of 120 hours are shown in figure 4. As can be seen from figure 4, the concentration of oil leached reduced dramatically with the increment of amount of the melamine resin added, and the variation amplitude of oil leaching for other reinforcing agents such as epoxy and polyethylene resins exhibits flatly. The diffusion quantity reached 2.69mg/L at 120 hours after adding melamine resin, which is lower than without reinforcing agent. The diffusion quantity could arrive 5mg/L through 120 hours, which meets the demands requested by national first order dispatching in China. The possible explanation could be that the high amount of reinforcing agents added could lead to the intensity of solidification of cement, and reduce the performance of leaching of oil in solidified blocks, resulting in the lower leachability.

CONCLUSIONS

The leaching behavior of oil from solidified oily sludge was investigated. The following conclusions can be derived from this study.

- The quantity of oil diffusion varies from 1.18 at 24 hours to 3.48 mg/L at 72 hours. The amplitude of oil diffusion within 72 hours is the most distinct and thereafter, the variation becomes slower.
- The diffusion quantity enhances from 2.01 to 2.77 mg/L with the increment of temperature under the range of 298-308K. The trend displays flat when the temperature is beyond 308K.
- The quantity of oil diffusion reduces from 3.82 to 2.80 mg/L with the increasing of the cement/sludge ratio under the range of 1.0 ~1.8.
- The diffusion quantity reaches 2.69mg/L at 120 hours after adding reinforcing agent of resins, which is lower than without reinforcing agent.
- The diffusion quantity could arrive at 5mg/L through 120 hours, which meets the demands requested by national first order dispatching in China.

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