

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The effectiveness of nitric acid as a desorbing agent for stripping adsorbed zinc and copper from two adsorbents derived from agricultural wastes, namely palm oil fuel ash (POFA) and coconut shell-based activated carbon, was investigated in this study. Under the experimental conditions selected for the desorption experiments, it was shown that a contact period of approximately three hours was sufficient to allow the zinc-POFA, copper-POFA, zinc-carbon and copper-carbon systems to reach equilibrium. Following an effective accumulation of zinc or copper by the two adsorbents, the solution of 0.125% nitric acid was shown to be capable of desorbing more than 95% of the adsorbed zinc and about 62% of the adsorbed copper from the POFA adsorbent and more than 92% of the adsorbed zinc and about 2% of the adsorbed copper from the activated carbon adsorbent. It can therefore be concluded that the 0.125% nitric acid is an excellent desorbing agent for stripping adsorbed zinc from both the POFA and activated carbon adsorbents and that it is a poor desorbing agent for stripping adsorbed copper from the two adsorbents, especially from the activated carbon.

The reusability of the two adsorbents was tested in five consecutive cycles of zinc adsorption-desorption. The quantity of zinc desorbed over the five cycles corresponded closely to the quantity loaded, indicating that almost complete recovery of the adsorbed zinc from the two adsorbents was readily achieved. However, a significant reduction in the zinc reloading capacity of the two adsorbents was observed from the second cycle onwards. It was shown that less than 15% of the zinc uptake capacity of the fresh POFA adsorbent and less than 11% of the zinc uptake capacity of the fresh activated carbon could be reused in Cycles 2 - 5. Such a low reusable portion of the zinc uptake capacity of the two adsorbents can increase substantially the cost of a technical application of the process. The 0.125% nitric acid solution limited the reuse potential of the two adsorbents possibly by causing damage to the adsorbents' binding sites as a result of the very acidic environment during desorption or causing a reduction in solution pH values which inhibit zinc uptake during reloading as a result of release of residual nitric acid from the adsorbent particles.

5.2 Recommendations

The present work resulted in identifying the solution of nitric acid with a strength of 0.125% as an efficient desorbing agent for releasing zinc sequestered on the POFA and activated carbon adsorbents into solution in a single cycle of adsorption-

desorption. The results obtained from studies involving multiple cycles of adsorption-desorption showed that while the 0.125% nitric acid was efficient in releasing the adsorbed zinc into solution, its application negatively affected the zinc capacity of the two adsorbents.

As discussed previously, the observed very limited zinc reloading capacity could be the result of low solution pH values during reloading due to the release of residual nitric acid from the adsorbent particles which had previously been exposed to the acidic desorbing solution. At low solution pH values, zinc adsorption equilibrium favours the solution phase, resulting in low zinc uptake by the adsorbents.

In order to confirm the above hypothesis, it is recommended that additional experiments on multiple cycles of zinc adsorption-desorption incorporating an alkaline washing step be conducted. Following desorption, the adsorbent particles should be immersed in an alkaline solution to neutralise any residual nitric acid attached to the structure of the adsorbent particles. This extra washing step would eliminate the possible release of residual acid during the subsequent zinc reloading step.

If the results of the above modified experimental approach indicate there is little reduction in the zinc reloading capacity, the 0.125% nitric acid solution can then be considered to be an efficient and practical desorbing agent for releasing adsorbed zinc into solution in multiple cycles of adsorption-desorption.

However, if drastic reduction in the zinc reloading capacity is again observed, it is very likely that the application of the nitric acid solution in the first cycle has caused substantial damage to the binding sites of the adsorbents, thus limiting their zinc reloading capacity in subsequent cycles.

To confirm the above hypothesis, it is recommended that analytical techniques such as electron microscopy or infrared spectroscopy be used to examine the surface architecture of the adsorbents. Analysis of the architecture of the adsorbents before and after the desorption treatment would provide information on the effect brought upon the adsorbent surface by the nitric acid desorbing solution.

If damage to the binding sites on the adsorbent surface resulting from the use of nitric acid as the desorbing agent is confirmed, future work should focus on searching more benign desorbing agents to replace the nitric acid solution. Potential

candidates for testing include metal chelating agents such as ethylenediaminetetraacetic acid (EDTA) and mineral salt solutions.

In the case of copper desorption from the two adsorbents, future work should obviously focus on testing new desorbing agents since the present work has identified the nitric acid solution as a rather poor desorbing agent.