

## Industrial water treatment

### Removing metal ions from industrial effluents and AMD

# A completed Water Research Commission (WRC) project has investigated the removal of metal ions from industrial effluents and acid mine drainage (AMD) by metal sulphide precipitation.

## Background

The purpose of this research was to further the understanding of metal sulphide precipitation in the treatment of AMD and metal ion impregnated industrial wastewater.

During the process of metal sulphide precipitation the physico-chemical properties of the precipitant material had a significant effect on the overall viability of the metal removal process. The aim of the work was to ascertain the conditions necessary for optimal metal ion removal and this was achieved by addressing the following objectives:

- Characterisation of the effect of operating conditions on the physical properties of the formed metal sulphide precipitate
- Investigation of properties that affected the solid-liquid separation characteristics of formed particles
- Investigation of factors with potential influence on the solid-liquid separation characteristics of formed particles.

## Results of the study

In line with the first objective, the current work showed that the contacting conditions with respect to the metal-sulphide ratio had a significant effect on the physical properties of the precipitant material. An excess amount of sulphide during contacting led to a stable colloidal suspension due to the highly negative zeta potential of the resultant particles.

Although this effect was observed in both the copper and zinc sulphide systems, it occurred to a greater extent in the copper sulphide system. This resulted in substantially more negatively charged particles of CuS than ZnS under similar conditions of precipitation.

Further work also suggested that metal sulphide particle aggregation was inhibited above a certain threshold value of zeta potential, and this threshold value was metal sulphide specific. Consequently, a correlation was developed between settling characteristics and zeta potential.

Particles with a large zeta potential magnitude formed more stable colloidal suspensions, while particles with a small zeta potential magnitude did not form stable suspensions.

Conventional surface modifying techniques, post-precipitation, were used to induce changes in the zeta potential of precipitant particles in order to investigate the subsequent solid-liquid separation characteristics. The three surface-modifying techniques studied were: effect of suspension pH, addition of sulphide, and addition of cations. All three factors were found to have a considerable effect on particle zeta potential and subsequent coagulation properties, although this was to varying extents.

The investigation of factors that potentially influenced solid-liquid separation led to the use of non-conventional particle surface modifying techniques. Post-precipitation, the particle oxidation of precipitant material was investigated with the aim of reducing the particle zeta potential in order to increase aggregation and consequently settling.

This was found to have a considerable effect on improving settling while maintaining a high metal ion recovery.

In addition to this, precipitation under controlled supersaturation was also investigated. This was achieved by using solid FeS as a sulphide source via dissolution.

The process was mass-transfer limited, and this was exploited as a control mechanism for sulphide dosing. Although supersaturation was found to be significantly reduced, the process was not viable due to encapsulation of the FeS particles by the precipitating pollutant metal ions.

## Conclusion

**Metal sulphide precipitation has shown potential as a method for the removal of metals from industrial pollutant streams.** Although its relatively low solubility products and fast reaction kinetics mean that the process has a number of challenges, it is still a superior choice to that of metal hydroxide precipitation.

The findings of the current work are that metal sulphide particles obey the DLVO theory. However, the reported threshold value for the promotion of aggregation of about -38 mV is difficult to achieve under viable operational conditions. The pH during precipitation either has to be very high, resulting in the need for a high dosage of pH modifiers, or the colloidal suspension has to be treated with significant amounts of coagulants. This reduces the viability of sulphide precipitation as a precipitation method.

This work has also shown that other mechanisms of inducing settling, such as partial oxidation of precipitant material, are effective, but only in synthetic mono-component streams. The consequence of using such a technique for

typical industrial multicomponent streams and AMD is that altering the solution redox not only affects the target material, but may induce catalytic reactions that may transform the precipitant material into an undesired product. Further studies with multicomponent systems would be required.

The last major finding is that using FeS as a slow sulphide release source for the precipitation of lower solubility product metal sulphides suffers from limitations that render it not viable for industrial use. The encapsulation of FeS by ZnS that was observed in the current process inhibited further dissolution of the sulphide source, thus stopping the precipitation process.

It is recommended that future work in this area focus on the production of a metal sulphide product that is easily separable from the industrial waste stream. Two of the most promising contenders for processes are electrocoagulation and magnetic field application. Both of these processes have the ability to address the biggest issue with metal sulphide formation – the difficulty of promoting settling – and both of them do so without the addition of any additional reagents.

### Further reading:

To order the reports, *Removal of metal ions from industrial effluents and acid mine drainage by metal sulphide precipitation* (**Report No. 2108/1/14**) contact Publications at Tel: (012) 330-0340, Email: [orders@wrc.org.za](mailto:orders@wrc.org.za) or Visit: [www.wrc.org.za](http://www.wrc.org.za) to download a free copy.