

EXECUTIVE SUMMARY

BACKGROUND

While research to date in South Africa has led to a detailed understanding of the biological sulphate reduction process and the implementation of a potential process, key aspects require further understanding and optimisation for the successful implementation of this technology.

The biological treatment process is partly motivated through its ability to generate easily separable metal sulphide precipitates. However, metal sulphide precipitation is well known to be an extremely difficult process to manage and control. Because of their low solubility, metal sulphide salts inevitably form extremely small particles that are difficult to separate from solution. However, in much of the literature on sulphate reduction processes, the metal sulphide "removal" is cited, without taking into account that the very small size of the solids formed might preclude them from being actually removed from the solution. An example is given below: "The reactor removed more than 97.5% of the initial concentrations of Cu, Zn and Ni, while only >77.5% and >82% of As and Fe were removed, respectively" (Jong and Parry, 2003). It is this issue that is the main focus of this research work.

The main aim of the research was to:

- * Understand the fundamental mechanisms in the metal salt precipitation component of the sulphate reducing bacteria process;
- * Define the operating conditions to achieve effective metal precipitation in a fluidised bed reactor as an individual unit operation in the sulphate reducing bacteria process.

The secondary aims were to:

- * Establish the nature of the relationship between the processing conditions and the reactor performance;
- * Develop an understanding of how the processing conditions influence the product characteristics;
- * Extend the new approach for supersaturation control to the sulphide/ bicarbonate system.

RESULTS AND CONCLUSIONS

In order to understand the metal salt precipitation mechanisms in the mixed sulphide/bicarbonate system that is characteristic of the sulphate reducing bacteria process, investigations were carried out into metal sulphide precipitation in both a seeded fluidised bed reactor and gaseous hydrogen sulphide bubble column.

- * The presence of bicarbonate ions in solution during the process was found to have no effect on the **nature** of the metal precipitate produced and only **metal sulphide** precipitate was formed during the process.
- * However, the presence of the bicarbonate ions in solution during the process had a significant effect in **enhancing the precipitation** of metal ions from solution, but this was at the expense of the particle characteristics, since the formation of **fine particles** in solution was found to be **higher** than previously reported.
- * It was found that **aggregation** of metal precipitate onto the seeds due to fine-grain aggregation was partly responsible for removal of some metal precipitate from solution. **Settling** of large particles at the bottom of the reactor due to fine-grain aggregation was possibly the main factor responsible for the observed metal removal efficiency.
- * Metal ion conversion during **mixed metal** sulphide precipitation is controlled by the pH-dependent solubility of the resulting metal sulphide salts.

- * Removal efficiency of the process for **mixed metal sulphides** is reduced by the poor inter-particle interaction due to the negatively charged surfaces of the individual particles.
- * Metal precipitation in the **bubble column** was found to be accompanied by a rapid drop in pH which caused the solution to become depleted of supersaturation. Thus, particle size enlargement through **aggregation** and/or flocculation **became inhibited**.
- * It was found that the level of supersaturation was ten orders of magnitude lower in the bubble column reactor than in the fluidized bed reactor. However, this **significant decrease in supersaturation** had a **negligible effect** on the particle size of the resulting precipitate.

The implications of this are that, even though metal sulphides are highly insoluble, and thus theoretically able to remove metals and sulphides to very low levels, in practical terms, the particle characteristics are extremely difficult to control.

At this stage, it is clear that, even with the mass transfer limitation introduced by using a gaseous source of sulphide, the supersaturation generated is many orders of magnitude higher than that required for controlled particle characteristics and some other method of particle control is necessary.