CHAPTER 5

CONCLUSIONS

5.1 CHEMICAL FE (II) OXIDATION

When iron (II) was oxidised chemically, the highest iron (II) oxidation rate achieved was 50.2 g Fe/(L.d) when no media was added. The results showed that the addition of $CaCO_3$ had a positive effect on the oxidation rate, however the addition of support media did not have the same effect. This finding can be ascribed to the fact that when $CaCO_3$ is added to the aerated iron (II) solution, the pH increases from 2.0 to 6.5. At pH higher than 6 the iron (II) becomes unstable in the presence of oxygen and thus the iron (II) oxidised to iron (III). The sludge formed during this reaction is composed of ferric hydroxide ($Fe(OH)_3$) and gypsum ($CaSO_4$), (as described in 2.4). It can be assumed that the two suspended solids act as catalysts to the oxidation reaction because the oxidation rate improved from 44.0 to 50.2. The investigation further showed that, the increase in number of iterations from 1 to 6 resulted in the increase in oxidation rates from 14.1 to 40.2 g Fe/(L.d). It was noticed that the suspended solids (catalysts) concentration in the reactor vessel increased.

5.2 BIOLOGICAL FE (II) OXIDATION

5.2.1 Batch studies

Iron (II) can be oxidised to iron (III) at low pH due to the presence of iron oxidising bacteria. The obtained results showed that the oxidation rate was influenced by bacterial growth, which can be increased by providing the following support parameters:

1) Temperature

The results as obtained from this study showed that optimum temperature for the biological iron (II) oxidation was 29^{0}C. At this temperature, the oxidation rate was 15.8 g Fe/(L.d).

2) pH

The optimum pH for the growth and catalytic activity of the *T. ferrooxidans* was found to be 2.0 as it provided the highest oxidation rate of 20.8 g Fe/(L.d).The oxidation rates at pH 1.7 and 2.3 were 15.4 and 11.4 g Fe/(L.d), respectively.

3) Air flow

It was found that the increase in the air flow (3, 5.6 and 8.9 L/min) resulted in an increased Fe (II) oxidation rate (7.8, 9.5 and 13.9 g Fe/(L.d), respectively). It can be concluded that when more air is available, the respiration rate of the *T. ferrooxidans* increase resulting in a faster iron degradation rates. The results show that sufficient air should be available when conducting the biological iron (II) oxidation.

4) Iron (II) concentration

The highest oxidation rate (27.0 g Fe/(L.d)), was achieved when the initial iron (II) concentration was 14.0 g/L. Increasing the Fe (II) concentration to 20 g/L resulted in a decrease in the oxidation rate. It can be assumed that the poorer results achieved in the presence of the higher Fe^{2+} concentrations can partly be attributed to the inhibition effect of ferrous and ferric iron on the growth of *T. ferrooxidans*.

5) Support media

Of the different support media tested (sand, rings, pellets, discard, anthracite, white GT, grey GT and brown GT), brown GT gave the highest oxidation rate (24.8 g Fe/(L.d)). It was concluded that GT has a high surface area, which accelerated the bacterial adsorption and biofilm formation. Due to the porosity of the GT structure, the air could penetrate easily to contact the oxidizing biomass. This result showed the importance of supplying sufficient air to the microorganisms in the formed biofilm.

6) Media concentration

The results of this study showed that increasing the number of GT plates from 5, 10 to 19, gave an increase in the iron (II) oxidation rate, 4.1, 7.2 and 10.2 g Fe/(L.d), respectively. It can be concluded that when the concentration of support media increase the micro organisms have enough surface area on which to adhere and as a result their growth multiplies.

7) Iterations

It was found that the iron (II) oxidation rate increased with the increased number of iterations, while the surface area of the support media decreased. When the number of iterations increased, the iron oxidising bacteria concentration in the reactor vessel increased as well, which resulted in an increased biofilm formation on the GT as support medium.

8) Nutrients

The oxidation rate of 8.4 g Fe/(L.d) was achieved when nutrients were added to the reactor vessel and when no nutrients were added the oxidation rate was 5.7 g Fe/(L.d). The finding shows that the *T. ferrooxidans* require the nutrients to build new cell material for growth.

9) CO_2

This investigation showed that the addition of CO_2 resulted in an increase in the oxidation rate of 6.1 g Fe/(L.d) as compared to the oxidation rate of 4.0 g Fe/(L.d) when no CO_2 was added to the reactor vessel. It can be concluded that the *T. ferrooxidans* uses CO_2 as its source of carbon for growth.

5.2.2 Continuous Studies

The results of the continuous reaction study confirmed the results as obtained from the batch studies. It was found that the highest iron (II) oxidation rate was 12.20 g Fe/(L.d) when GT was used as the support media and when the nutrients were added. It was further concluded that the optimum HRT for the continuous study was obtained at 8 h. Thus the faster the feed flow rate, the better the oxidation results. These results are beneficial for the mining industry as it indicates that optimal iron oxidation rates can be achieved at low HRT when treating higher volumes of mine water.

5.2.3 Kinetic studies

Kinetic studies showed under acidic conditions, the rate equation for the biological oxidation is determined by the surface area of the support medium.

5.3 RESPIROMETER STUDIES

The results as obtained from the respirometry studies showed when more oxygen is utilised the iron (II) oxidation reaction becomes much faster. The highest oxygen cumulative rate obtained was 89.1mL under the conditions that, the iron (II) concentration was 15 g/L, GT was used as a support media, and the addition of 1mL biomass and 2mL nutrients.

5.4 GENERAL DISCUSSION

The results of this study showed that the highest oxidation rate of 24.8 g Fe/(L.d) was obtained when the temperature was 29 ºC, pH 2.0, when GT was used as support media when the nutrients and CO_2 were added to sustain the bacteria. The results do not compare favourably with the results of Nemati and Webb (1996) (as described in Table1). Nemati and Webb conducted their study under the following conditions: temperature was 30 ºC, pH 2.0 and polyurethane foam BSP was used a support media. The highest oxidation rate achieved by Nemati and Webb can be ascribed to the fact that in their study pure cultures of *T. ferrooxidans* were used while in this study microorganisms which are naturally present in the AMD were used. Nemati and Webb furthermore utilized polyurethane foam BSP as support media as opposed to GT in this study. The advantage of polyurethane foam BSP is the higher surface area, however, due to the lightness of the polyurethane foam BSP, the particles float in the reactor which in a full scale plant result in disturbances and thus to malfunction of the plant. GT as a support media offers the benefit that it does not float in water and it is cheaper.

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