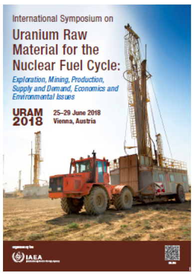

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Investigation of Key Parameters for Effective SDU Precipitation

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INTRODUCTION

While precipitation of sodium diuranate (SDU) has been practiced commercially from leach liquors since the 1950's, there is very limited information on the impact of operating conditions on the efficiency of uranium precipitation from the "low-tenor'liquors that are produced from the carbonate leaching of carnotite in calcrete ores.

ANSTO Minerals recently carried out a program of work investigating direct SDU precipitation from carbonate/bicarbonate leach liquors. A number of variables were examined to assess their impact on the precipitation efficiency, including carbonate feed concentrations, terminal caustic concentration and seeding. In addition to a batch test work program, a continuous mini-plant was also operated.

WORK PROGRAM

Test work was completed on pregnant leach solution (PLS) produced from bulk leaching of a carnotite in calcrete ore. Two different leach regimes were used to generate PLS with differing concentrations of Na2CO3 and NaHCO3 (high bicarbonate - 12 g/L NaHCO3, 33 g/L Na2CO3 and; low bicarbonate –7 g/L NaHCO3, 31 g/L Na2CO3). The uranium concentration was ˜ 1 g/L U3O8 in both cases. The same solutions were used in both batch laboratory-scale tests and in a continuous mini-plant.

Laboratory batch tests were conducted by heating the PLS to the target temperature (70 or 80 ℃) and adding a pre-determined quantity of SDU seed or uranium stock solution, to achieve a target total U3O8 concentration (1-6 g/L U3O8). Typically, a 2 h seeding time was allowed at temperature to promote dissolution of the seed. After the seeding time, NaOH (50 wt% solution) was added to consume the NaHCO3 and obtain the target caustic concentration (6 or 8 g/L) in solution. Samples were withdrawn regularly for analysis by ICP for U and V concentrations.

RESULTS AND DISCUSSION

Impact of Bicarbonate and Total Carbonate Concentrations
A series of tests were completed examining the impact of total carbonate concentration in the PLS on SDU precipitation. The total Na2CO3 ranged from 38 –78 g/L, after reaction of all of the NaHCO3 with NaOH. Lower uranium in barrens was achieved from solutions containing lower carbonate concentrations. When considered in the context of an entire flowsheet and the preceding leach conditions, this is an important observation. Bicarbonate is required for uranium extraction but it is also generated during the leaching of carnotite in calcrete ores. The chosen Na2CO3/NaHCO3 reagent concentrations at the start of the leach will therefore define the composition of the PLS being fed downstream to SDU precipitation. The higher the terminal bicarbonate concentration in leach, the more caustic required to neutralise it (Equation 1), resulting in a greater total Na2CO3 concentration.

NaHCO3 + NaOH -> H2O + Na2CO3
Equation 1

A higher concentration of bicarbonate in the PLS was shown to increase the dissolution of seed, resulting in a higher dissolved uranium concentration prior to precipitation. However, the improved dissolved uranium concentration prior to precipitation was offset by the increased total carbonate concentration obtained, resulting in higher concentrations of uranium in barrens.

Impact of Seeding

Seeding is recognised as an important component of SDU precipitation in a continuous operation and our results support the need for seeding. The best uranium in barrens achieved in tests completed in the absence of seeding was 163 mg/L U3O8 (138 mg/L U) whereas the presence of seeding under the same operating conditions reduced the uranium in barrens to 57 mg/L U3O8 (48 mg/L U).

Comparison of target seed concentrations (4 and 6 g/L U3O8), however, showed that while there was a reasonable improvement in the amount of dissolved U after seeding at 6 g/L U3O8, the final difference in U in barrens was minimal. It should be noted that with greater seed dissolution, more caustic is subsequently required to re precipitate the uranium (Equation 2).
6 NaOH + 2 Na4UO2(CO3)3 -> Na2U2O7 + 6 Na2CO3 + 3 H2O
Equation 2

Further testing looked at the impact of "total dissolved"uranium concentration on precipitation (over the range of 1-6 g/L U3O8), by spiking the PLS with a uranyl carbonate solution rather than seeding with solid SDU product. A dissolved U3O8 concentration of 3 g/L was shown to be optimum for producing the lowest uranium in barrens, with the lowest consumption of caustic. There was a small kinetic impact on precipitation at higher concentrations (4, 5 or 6 g/L U3O8), which may permit a reduced reaction residence time, although at the cost of higher caustic consumption.

Impact of Caustic Concentration

A higher terminal caustic concentration has a positive impact on the kinetics of precipitation. Considerably lower uranium in barrens were observed at 8 g/L NaOH, compared to 6 g/L, particularly after the first 30 minutes of precipitation. With increasing residence time, the gap narrows, although the final uranium in barrens after 8 hours precipitation was still lower at 8 g/L NaOH (by 9 –16 mg/L U). This result suggests that operating at a lower NaOH target may be offset by increasing the precipitation residence time and has the added benefit of reducing costs due to a lower caustic requirement.

Impact of Temperature

Comparable tests completed at 70 and 80 °C showed a significant increase in seed dissolution at the higher temperature, therefore increasing the concentration of dissolved uranium in solution. The subsequent impact on SDU precipitation, however, was not significant.

CONCLUSIONS

The carbonate and bicarbonate concentrations in the feed liquor were determined to have a significant impact on the success of SDU precipitation. Our investigations have shown that a higher total carbonate concentration in the feed solution is a key factor impeding SDU precipitation, resulting in an increased concentration of uranium in the barren solution. The concentrations of the preceding leach reagents (Na2CO3 and NaHCO3) are therefore important as this will define the total carbonate concentration in the SDU precipitation circuit.

The caustic concentration was demonstrated to have a kinetic effect on the precipitation reaction and consequently residence time may also be critical, depending on the terminal caustic concentration selected for a given flowsheet. Higher temperature was shown to improve the dissolution of seed but did not show a significant impact on the final precipitation result.

Greater seed dissolution was also achieved in the PLS which contained a higher concentration of bicarbonate but the resulting total sodium carbonate concentration was higher from this PLS and this had a negative impact on the precipitation and final U in barrens.

Seeding was demonstrated to be necessary for effective precipitation. The complex relationship between dissolved uranium concentration and the presence of seed on SDU precipitation has been investigated to fully define the nature and amount of solid seed required.

Country or International Organization

Australia

Primary author: Dr BURLING, Suzanne (ANSTO Minerals)

Co-authors: Mr MALEY, Mark (ANSTO Minerals); Dr RING, Robert (ANSTO Minerals)

Presenter: Mr MALEY, Mark (ANSTO Minerals)

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