ALTA 2019 DEVELOPMENTS IN URANIUM-REE IX PANEL DISCUSSION

May 2019

The panel discussion was held Thursday 23 May 2019, immediately following the Uranium-REE sessions at ALTA 2019 in Perth, Australia.

Panel Chair: Alan Taylor (AT), ALTA Metallurgical Services (Australia)

Panel Participants (left to right): Marthie Kotze (MK), LANXESS (South Africa); Grenvil Dunn (GD), Orway Mineral Consultants (Australia); Johanna van Deventer (JVD), Purolite (South Africa); Dmitrii Kondrutskii (DK), Axion - Rare-earth and Noble Metals (Russia); Karin Soldenhoff (KS), ANSTO Minerals (Australia).

Editor's Note*: The contributions of the panel members and delegates are not presented verbatim, but rather have been paraphrased and condensed for clarity and brevity. They are not necessarily recorded in order but are grouped into major topics. Also, it is not feasible to include all contributions made during the discussions, and they are limited to some that are representative of the key points raised and debated.*

Future Wish List for IX in Uranium and REE Processing

AT (chair) began by asking the panel their views on a future wish list for IX resin technology for REE and uranium processing from the user's and manufacturer's perspectives - i.e. what are the aims, what would we like to do and where are we going?

KS (panel) said that one item she would have on the wish list is for resins to be able to extract REE from sulphate solutions, while leaving ferric behind. Some resins are capable of achieving this from nitrate solutions but not sulphate solutions.

DK (panel) advised that Axion would like to have resins with a high capacity in the presence of chlorides, as some Russian uranium deposits currently have high chloride concentrations. Another wish list item is higher mechanical strength, based on customer requirement. In his presentation he highlighted the Russian test using a rolling steel ball mill for a period of 1 hr and mentioned that customers demand resins that can withstand this test for over 5 hours, as they seek mechanical strength and long resin life for their resin-in-pulp. Customers are also asking for resin size distributions of 0.8-2.5mm, compared with the current sizes range of 0.3-1.2mm.

JVD (panel) added that the wish list of customers typically includes better selectivity, higher strength, higher capacity, and lower cost. If the resins were cheaper, durability wouldn't be an issue. An important issue for Purolite is that they identify some wonderful functional groups, but they are environmentally unfriendly to produce which would increase the price or completely rule them out for commercial production. So aiming for wish list items has to be balanced by the reality of commercial production issues.

MK (panel) speaking from a producer's point of view, customers want fast kinetics and extreme durability. However, rather than aiming to meet the wish list, collaboration between suppliers and design engineers needs to be facilitated to select the optimum equipment design and operating conditions to minimise resin losses. For example, these days we have mono-dispersed particles which are bigger than 800 microns. However, if you go to 2.5 microns you will have better screen fluxes, but there will be a compromise in kinetics. So you have to find the optimum between the desired engineering size and the actual resin size.

GD (panel) said that, as a user, his wish list item would be resins for uranium extraction that can operate in environments greater than 2 molar chloride concentration and still deliver good extraction results. There are very few possibilities available, and those that do lack the desired selectivity for uranium against iron loading.

From a bead size perspective, the Kayelekera uranium operation in Malawi were struggling with screen separation in their resin-in-pulp system and he thought they were operating with 1.4 mm LANXESS resin just prior to shut-down, and asked for confirmation from other panel members.

JD (panel) replied that as far as she knew Kayelekera started with Dow 920U 800 micron resin, then used a Purolite 800-850 micron resin.

GD (panel) added that they were certainly talking about going to 1.2 mm and he thought they went to 1.4 mm.

MK (panel) doubted that there is a supplier producing that size.

JD (panel) added that one of Kayelekera's issues was the upfront screening system, where oversize went into the resin section. She is unaware whether they found a resin of the desired large size.

MK (panel) seconded JVD's (panel) point that Kayelekera did not have good milling and screening control, so they had oversize going into the resin-in-pulp system.

Standard Procedures for Resin Evaluation

Rajeev Bhavaraju (RB), LANXESS (Australia), floor asked for comments from the panel on a question from a customer as to why there isn't a set of standard procedures for resin evaluation? For example, in regard to mechanical strength both the Russian ball mill test and the attrition test are used. Standardisation would make the resin evaluation process easier and more cost effective for end users.

MK (panel) responded that no one has proven that any single test gives a clear, direct and quantifiable link that will allow one to predict resin losses. For instance, the Russians use the steel ball test and correlate it with additional data, and they believe it to be most effective; however this is difficult to confirm. Mintek in South Africa ran multiple series of testing procedures which produced highly variable results. A test conducted on a $2m^3$ CSTR (Continuously Stirred Tank Reactor) test plant yielded different results for the attrition tests and steel ball-mill tests. Until the correlations obtained from these tests are concordant and can be confirmed, we will have to continue to run tests to find a reliable cost-efficient procedure.

JD (panel) added that durability isn't the only test required to determine the effectiveness of a resin. Various factors such as osmotic shock as it changes from the loaded and eluted forms and the shear and percussion actions that occur in a resin-in-pulp circuit are contributing factors to resin degradation. The Russian ball mill test is effective for RIP because it has been the common mode of extraction in Russia for decades. In other industries, the breaking weight test is used (where a force is applied to a resin bead to measure the amount of force it can handle before breaking irreversibly). The reason a standard test doesn't exist is because there are so many factors and opinions that come into play when assessing resin damage; it is not because of a reluctance to share information.

James Rosie (JR), Purolite (UK), floor agreed with RB (floor) that it would be nice to test resins consistently with standard tests, but most of the tests for resin companies have to be QC tests during manufacture. The test has to be relatively quick and consistent with instrumentation, and needs to be done within a few hours or overnight with standard equipment. It's not possible to send resin outside for specific ore milling tests because it would take too long while there is a batch of resin in quarantine in the factory waiting to be passed.

Resin Breakage and Make-Up and the Design of IX Systems

Irena Ivanova (II), Ausenco (Australia), floor reported that she has been dealing with resins in different engineering applications for close to 10 years, and the 'golden question' which has never been answered is whether to use pachucas or reactors? As engineers, Ausenco need to be able to advise clients what is the best design for resin applications. There is a need for comparative information from operational plants such as the two plants in former-USSR and Kayelekera in Malawi, also to draw on the extensive Pachuca experience in the former USSR. She ran Mixtec reactors with resin for about three months and saw no wear or resin degradation whatsoever. There are no reliable figures available in the industry for resin breakage rates, and the available information tends to be just hearsay. It's an important issue which needs to be resolved.

GD (panel) said that based on his understanding, the operating NIMCIX systems in Africa are reported to have losses between 5-7% through bead breakage through the full cycle of loading and elution. He hasn't any information about the Porter IX system used at Rossing.

MK (panel) said that she is not sure whether the claimed value of 5-7% breakage for the NIMCIX system has been confirmed. It does not operate in pulp, but it does involve pumping of the resin. Responding to II's (floor) query about long term stirred tests, Mintek have found that breakage only occurs when you integrate the process to include pumping, screening, and resin shock due to contact with the acid.

Murdoch Mackenzie (MM), Private Consultant (Australia), floor reported that the Porter system can lose a lot of resin. Rossing resin losses were initially often very high, in the order of 20%-25%, which may have been due to the way it was run. He would expect the present figure to be lower.

GD (panel) added that Rossing didn't initially have linear screens at the back.

JVD (Panel) agreed and reported that they added them a few years ago and their losses immediately dropped significantly. Responding to II's (floor) query, there are simply too many variables to provide a single number for resin losses. For example, the upgrade ratio on the resin varies with the product being extracted, e.g. gold, uranium or base metals. There could also be different solids contents and different resin concentrations in the RIP reactors. All of these factors contribute to the resin loss figure. Then there are design issues and operational and mechanical variables, for example an operator may have forgotten to close a valve and the resin ends up in tailings an cannot be recovered. All of these and many more variables mean that it is not feasible to quote a single resin loss figure.

AT (chair) asked DK (panel) to comment on the resin loss from traditional Russian Pachuca type systems, and whether newer resins are being used today.

DK (panel) Responded that from his experience, a resin top-up 5-10% is typical for Axion's Russian customers.

Axion's customers typically prefer specially developed resins for their operations such as pyridinium rather than the more usual tetra-methyl ammonia type resins, and are willing to pay more for superior performance.

Glenn Jobling (GB), Adelaide Control Engineering (Australia), floor added that in selecting IX equipment, the view on 'what works best' depends on the locale. Typically, the USA favours fixed beds, Kazakhstan commonly uses the U-Tube and South Africa uses NIMCIX. There are very few operations that have implemented different technologies at the same time, and therefore it is difficult to directly compare them. Langer Heinrich in Namibia is an exception with both fixed bed and NIMCIX systems; however the lack of information on how the plant has been operated makes it difficult to make a valid comparison. Additionally, some countries and engineering companies have differing levels of skills and expertise with certain types of equipment.

Solvent Impregnated Resins

AT (chair) reported that in the ALTA 2018 Nickel-Cobalt-Copper panel discussion it was noted that the very high cost made it difficult to justify the development of new IX resins and SX extractants. This has led to the development of synergistic SX systems and resins impregnated with SX extractants to achieve greater selectivity. He asked the panel whether there was a future for impregnated resins in uranium or REE processing.

JDV (panel) said that we will see more impregnated resins because some of the solvents out there have exciting possibilities, and solvent extraction is sometimes tricky to use due to considerations such as fire risks. There's also the possibility of mixing different solvents and then impregnating that into a resin to obtain higher selectivity. Nowadays we are getting more complex ores and users are demanding higher product purities, and we need to look at new and innovative ways of achieving that.

KS (panel) added that with impregnated resins there are likely to be applications in purification. For instance, for a product stream with some troublesome impurities, impregnated resins and the range of solvents (which would offer a wider range of functional groups), provide a relatively low risk option, especially as it will require relatively small quantities of resin.

AT (chair) asked whether solvent extraction manufacturers are happy for resin manufacturers to use their products? Traditionally, they are competitors for some applications. Also, are impregnated resins stable over time, and is there any historical data?

MK (panel) pointed out that during the presentation on impregnated resins in the sessions there was a comment that Impregnated resin has been used for years in Canada in a Nickel refinery and by Anglo in South Africa. Resin top-up is generally not because of leakage of the solvent from the resin, but mostly because of fouling such as ferric loading onto resin impregnated with DEHPA and has to be removed. However, with high upgrade ratios such as for zinc IX, the iron build-up is slow.

Process engineering design is critical and has to cater for the resin. For example, DEHPA impregnated resins are sensitive to pH changes and sodium hydroxide solution cannot be put through them due to adverse affects.

GD (panel) asked whether the organic that is impregnated onto the resin is eluted by the aqueous phase over time, and if so, how long does that take? He is aware that Port Colborne has used OC10-26 (Lewatit® resin impregnated with DEHPA) for zinc removal for over 20+ years, but he hasn't seen any data on how long the resin lasts.

MK (Panel) advised that as in solvent extraction, the solubility is determined by the operating pH. For example, the resin hasn't been depleted for 2 years in a plant operating at pH 2.5. However, if you are operating in pH conditions with high solubility, it will be depleted quickly.

Jack Bender (JB), BASF (USA), floor reported that BASF have been testing SX systems using extractants without diluents in which the extractants are put onto backings. They have found that, because of the extremely low solubilities of the extractants in water, the loss of extractant is minimal. This tends to support the slow loss of extractants from impregnated resins as reported in the Purolite presentation on impregnated resins in the earlier sessions.

KS (panel) commented that solvent impregnated resins have been studied at universities for the last 10 years. Typically the solvent with diluent was impregnated into the bead's substrate then the diluent was evaporated leaving the solvent essentially absorbed on the surface. It was found that leakage of the solvent from the resin was an issue using this procedure. But in the current procedure the solvent is actually mixed with the resin during the manufacturing process so that the solvent is effectively contained and therefore the longevity is significantly higher. Unfortunately, the same name is used for both procedures which can cause confusion

DK (panel) commented that he believes that there is a big potential for impregnated resins in Russia.

IX Versus SX for Uranium Recovery from Phosphoric Acid

AT (chair) asked the panel to comment ion exchange versus solvent extraction for the recovery of uranium from phosphoric acid - where are we headed and what is the long-term best process?

KS (panel) pointed out that in her keynote presentation she mentioned that ANSTO spent quite a few years developing the PhosEnergy process in collaboration with Urtek in which they considered both SX and IX. Phosphoric acid is an aggressive process which results in the presence of solids, cruds and organics in the feed to uranium recovery, and they concluded that IX is a better fit that SX. Also, IX is non-intrusive to the rest of the process.

Glenn Jobling (GB), Adelaide Control Engineering (Australia), floor added that ACE built the PhosEnergy demonstration plant for ERTEK and PhosEnergy in 2012/2013. It ran successfully but has since been mothballed due to the uranium price.

DK (panel) advised that there is interest in Russia in using resins for recovering REE from phosphoric acid rather than uranium.

Summary of Key Points

- The future “wish list” for IX of uranium and REE includes resins for the selective extraction of REE from sulphate solutions, resins for uranium extraction from high chloride solutions, resins with higher strength and larger bead size for resin-in-pulp applications, and closer collaboration between suppliers and design engineers to select the optimum equipment design and operating conditions to minimise resin losses.

- Industry standard testing procedures are needed for resin evaluation suitable for resin producers, engineering firms and operations.

- Industry collaboration to record resin breakage and make-up figures for the various IX system designs and process applications to assist with the design of new facilities.

- Solvent impregnated resins offer the ability to enhance the selectivity of resins, especially for product purification applications. It has been commercially proven that the current manufacturing process of mixing the solvent and resin results in slow leakage of and low make-up of the solvent compared with the older surface absorption procedure.

- IX was shown to be a better fit than SX for the recovery of uranium from phosphoric acid in the development of the PhosEnergy Process at ANSTO in Australia. The process has been successfully operated on a pilot and demonstration scale.

The Editor acknowledges the work of the student volunteer from Curtin University, Wayne Zaccheus, for providing detailed notes on the discussion.

Application of Membranes is the featured topic for the ALTA 2020 Uranium-REE Forum and Panel, which will be held 28 May in Perth, Australia.

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ALTA Panel Notes