SPOTLIGHT

on chemistry of processes for recovery of gold on activated carbon

by W. A. M. TE RIELE*

The National Institute for Metallurgy was the venue for a one-day colloquium on 'The Chemistry of Processes for the Recovery of Gold on Activated Carbon'. Organized by the South African Chemical Institute (Southern Transvaal Section) in collaboration with the National Institute for Metallurgy (NIM) and the South African Institute of Mining and Metallurgy, the colloquium attracted tremendous interest from the mining industry. Some 300 metallurgists, engineers, and chemists were brought up to date on advances in this technology made by scientists of NIM and the Anglo American Research Laboratories (AARL). Considerable progress has been made in recent years in the achievement of an understanding of the mechanisms of adsorption and elution of gold, and in the design of a suitable electrochemical cell for the recovery of gold metal from the eluate. It is quite clear that the major thrust in this area is now coming from within the Republic of South Africa.

In his opening address, Dr L. Alberts, President of NIM, welcomed the delegates and expressed his appreciation of the valuable collaboration that was taking place between research scientists and members of the industry, resulting in rapid implementation of this promising technology.

Review of Processes

Dr P. A. Laxen, of NIM, reviewed processes for the recovery of gold and silver using activated carbon: these include the treatment of only the slimes fraction, the use of fine or granular carbon, and the recovery of gold values either by smelting of the loaded carbon or by elution. A saving of half the capital cost could be achieved by use of the carbon-in-pulp (CIP) process instead of the relevant section of the conventional process. For this reason, Union Corporation had decided to adopt the CIP process for their BEISA project, which is scheduled to come on stream during 1981 and will treat 100 000 tons of ore per month. Dr Laxen listed a number of potential processes for the South African situation, and outlined in some detail a favoured CIP flowsheet based on the experience gained on a number of small local plants.

Adsorption and Elution

Dr R. J. Davidson, of AARL, presented his findings on factors that influence the adsorption of gold onto activated carbon and methods of elution. Liquid-phase variables (such as ionic strength, cyanide concentration, and pH), as well as the character of the carbon (particularly the zeta potential and the ability of carbon to adsorb a mineral acid), were found to influence the adsorption process. Dr Davidson proposed a mechanism of adsorption that involves the consumption of cyanide and the formation of ammonia and bicarbonate ions. A large number of eluants had been investigated, including sodium sulphide solution, liquid ammonia, thiocyanate, acetonitrile, and organic reagents such as acetone and alcohols. Though many of these had been effective, practical considerations such as fire and explosion hazards, and gradual poisoning of the activated carbon, made them unsuitable for an industrial process. The favoured elution technique developed at AARL involves treatment of the loaded carbon in a fixed-bed column with hydrochloric acid to remove calcium carbonate, followed by contacting of the carbon with a solution of 5 per cent sodium cyanide and 1 per cent sodium hydroxide, and subsequent elution of the carbon with demineralized water. The operation takes place between 90 and 110°C, and is completed in about 5 hours.

Exothermic Gold Adsorption

An interesting paper dealing with mechanisms of the adsorption of gold and other metals onto activated carbon was presented by Dr G. J. McDougall, of NIM. She showed the adsorption process of gold from a cyanide solution to be uniquely different from other adsorption systems. A simple anionic-exchange mechanism, which occurs in most applications of resins, is not applicable to the gold cyanide–carbon system. The adsorption step was shown to be exothermic, and was promoted by the presence of hydronium, calcium, and potassium ions. The role of chemical reduction was highlighted. In gold adsorbed from chloride medium, reduction to metallic gold takes place on the external surface of the carbon. Using the technique of X-ray photo-electron spectroscopy, Dr McDougall had shown that gold adsorbed from cyanide medium was reduced to an intermediate oxidation state of +0,3. Also, the reduction potential of the carbon greatly influenced the adsorption. This feature distinguished it from the adsorption of nickel and silver under similar circumstances.

Electrowinning of Gold

The period after lunch was devoted to the electro-

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winning of gold from carbon eluates. Mr J. Taylor outlined the results obtained at AARL from a number of different types of electrochemical cells. These included plate electrodes, fluidized-bed electrodes, and different configurations of anode and cathode using an ion-exchange membrane between the two compartments and a steelwool cathode. A cylindrical design with concentric electrodes separated by a membrane had been found to be the most satisfactory, and had been tested extensively. Silver had been found to plate before gold, and the effects of the circulating rate of electrolyte through the cell and of gold concentration on the gold plating had been investigated. A cell with a membrane area of 0,8m^2 had been found to be capable of reducing the gold concentration from 2000 to 10 p.p.m. at an average plating rate of 8 kg of gold per day.

Dr R. L. Paul outlined the approach taken by scientists at NIM towards the development of a suitable electrochemical cell for the recovery of gold from carbon eluates. A consideration of the cathodic and anodic reactions and the desirability for a continuous, single-pass cell capable of high extractions, led to the design of the NIM cell, which has a relatively thin, rectangular bed of carbon particles as the cathode clamped between two ion-exchange membranes, with two parallel stainless-steel plates on the outside forming the anode. A solution of caustic soda is circulated through the anolyte compartment while eluate is passed through the packed bed. Criteria have been established for good distribution of gold across the bed, and the effect of flow velocity, particle size, and bed length on the extraction efficiency have been quantified. The plated gold is recovered from the carbon particles by a reversal of polarity, anodic dissolution of the gold in a solution containing potassium cyanide and potassium hydroxide, and replating of the gold on titanium cathode sheets mounted outside the cell. Such a procedure has been successfully tested on a pilot-scale, which produced cathodes plated with 1 kg of high-quality gold.

Activated Charcoal

An interesting presentation on the manufacture, properties, and application of activated charcoal was made by Dr D. Heroes, of Chemviron (Belgium).

Analysis of Carbon

The techniques used in the chemical analysis of metals adsorbed on carbon and present in gold cyanide solutions were outlined by members of the Analytical Chemistry Division of NIM. Mr R. C. Mallett dealt with three different methods of analysis using atomic-absorption spectroscopy, and with the development of an on-line facility for the determination of gold values in solution with a lower limit of 0,002 p.p.m. Mr J. J. Jacobs explained the application of X-ray-fluorescence spectrometry to the analysis of metals on carbon, and Mr A. E. Watson presented results obtained by the alternative technique of emission spectroscopy with an induction-coupled plasma source.

Party

The day ended with a cocktail party, which was sponsored by Floccotan and Davy-Filtron.

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