Towards mineral beneficiation: from basic chemistry to applications

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Summary

The role of mineral beneficiation in the survival, growth, development and sustainability of a developing economy cannot be overstated. Our development as a human species has always been involvedly linked with the use of mineral resources from the stone, bronze and iron ages through the early modern eras to the present. In the current modern era, characterized by highly technological equipment, fourth industrial revolution (4IR) and new energy technologies, the role of mineral beneficiation has been elevated. Precious metals find use in the fine chemicals and petrochemicals industry, fuel cells, electrical and electronic products, medical and dentistry applications, jewellery, autocatalysts, and glass and ceramics. The markets for precious metals keep growing and the supply does not meet demand. The development of methods for recovery of metal value from feeds of mineral ore solutions, solutions of spent secondary resources and from mining wastewaters remains of great importance. Further beneficiation strategies for utilization of mineral products in other "value-added" applications are also important for the growth of the mineral markets. The usage of platinum, palladium and rhodium in the autocatalyst industry has grown significantly and this has further elevated the importance of platinum group metals (PGMs), but other areas of application of the strategic metals need to be harnessed. The four stages of beneficiation, namely, primary, secondary, tertiary and final stage, provide an opportunity to beneficiate to greater value for domestic or export use. Our own research work is engaged in several of these stages, from hydrometallurgical recovery of base metals and platinum group metals from feeds of primary mining and solutions of waste secondary resources such as spent catalytic converters and e-waste to the use of metals in "value added" products such as metal-based catalysts for the fuel industry and in metallodrugs. Examples of "value added" products include rhodium as a promoter in molybdenum sulfide as a catalyst for hydrodesulfurization of fuel oil, vanadium as a catalyst in oxidative desulfurization of fuel oil, vanadium and palladium as therapeutic agents for diabetes and cancer, respectively. Current and future work involves (i) the development of metal-selective scavengers to recover lost metal value in mining wastewaters, and (ii) the design of metal-based catalytic materials for refinement of bio-based oils to biofuel as well as for production of green LPG through hydroprocessing. Our work centres around both basic and applied chemistry towards mineral beneficiation and with a bias towards greener production.