Functional surfaces from complex solutions with electrochemically assisted aqueous reduction

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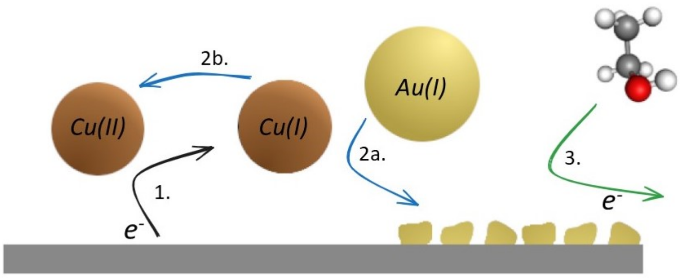
The efficient use of available resources has gained importance in recent years due to the environmental costs of primary production. For metals, there is increased interest in tehcnologies that can efficiently utilize secondary and lower grade raw materials as demand is increasing and high quality deposits are gradually exhausted.[1] In the hydrometallurgical route of metals production, valuable metals such as gold or platinum may be present in such low concentrations that their recovery with conventional methods is not attractive. Selective recovery of the valuable metals with conventional separation steps is made more challenging by orders of magnitude higher concentrations of base metals such as copper or iron.[2] As such, there exists a need for methods that can efficiently valorize the noble metals from such complex solutions.

Our group recently introduced the electrochemically assisted aquoeus reduction (EAR) method for selective recovery of gold from chloride solutions with high copper concentration.[3] In this method, an applied potential or current pulse reduces the abundant Cu(II) to Cu(I) in the vicinity of the electrode, which then acts as reductant for Au(III) or Au(I) due to their nobility difference (Scheme 1). In situ studies with an electrochemical quartz crystal microbalance showed how changes in solution and applied electrochemical parameters affected this new recovery process.

Furthermore, as gold could be recovered onto the electrode in the form of nanoparticles, this method represents a new path for preparing functional noble metal surfaces from complex, unoptimized solutions via electrochemistry. Here, the recovered particles were used for electrochemical ethanol oxidation, and the impact of changes in the EAR recovery step on the catalytic properties were investigated. To summarize, the work reveals how EAR can be used to make functional sufraces from complex solutions, and links the recovery conditions to catalytic properties.



Scheme 1. Schematic of 1.electrochemical Cu(II) reduction, 2. spontaneous gold reduction by Cu(I) ions and 3. eletrochemical ethanol oxidation on deposited particles.

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References

1 J. Spooren, K. Binnemans, J. Björkmalm, K. Breemersch, Y. Dams, K. Folens, M. González-Moya, L. Horckmans, K. Komnitsas, W. Kurylak, M. Lopez, J. Mäkinen, S. Onisei, K. Oorts, A. Peys, G. Pietek, Y. Pontikes, R. Snellings, M. Tripiana, J. Varia, K. Willquist, L. Yurramendi and P. Kinnunen, *Resources, Conservation and Recycling*, 2020, **160**, 104919.
2 L. Cui, K. Yliniemi, J. Vapaavuori and M. Lundström, *Chemical Engineering Journal*, 2023, **465**, 142737.
3 R. Herrala, Z. Wang, J. Vapaavuori, M. Lundström and K. Yliniemi, *J. Phys. Chem. C*, 2023, **127**, 16099–16109.