ELECTROPLATING WASTEWATER:

Pollution Control and Regeneration

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Pollution control legislation is affecting electroplating operations by increasing the economic penalties associated with the inefficient use of raw materials. For example, the loss of raw materials in the wastewater can result in five distinct cost items:

- Replacement of the material
- Removal of the materials from the wastewater before discharge
- Disposal of the removed materials
- Replacement of the water
- Processing cost of the wastewater by local sewer authorities

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In response to these increasing costs, plating shops are applying various separation processes to reclaim chemicals from the rinse water and thus allow the reuse of both the raw materials and the water. Several processes applicable for recovery of electroplating waste streams include the following:

- Evaporation
- Electrodialysis
- Reverse osmosis
- Electrolytic cell processing
- Ion exchange
- Coupled transport membranes

Evaporation

Evaporation is the simplest recovery technology in terms of the principles involved. It achieves the recovery of the chemicals by allowing the wastewater to evaporate (distillation or atmosphere), until the concentration of the chemicals is high enough to warrant their recovery and reuse. If a distillation method is used, the water itself can be condensed, collected, and returned to the process; this is usually impossible with atmospheric evaporation. Because of the higher recovery costs associated with dilute waste streams, countercurrent rinsing is recommended. By using countercurrent rinsing, the chemical concentrations can usually be built up to levels high enough for economic recovery.

There are four general types of evaporators available:

- Rising film evaporators
- Flash evaporators using waste heat
- Submerged tube evaporators
- Atmospheric evaporators

Before selection of any type, careful consideration must be given to all the variables including space, process specifications, volume of the waste stream, type of plating, available heating sources, operating costs, and, of course, capital investment and payback.

Electrodialysis

Electrodialysis is one of the more recent technologies applied to the recovery of plating chemicals from rinse solutions; it is a membrane process that is used to remove ions from solution. This is accomplished through ion-exchange membranes under the influence of an electric potential applied across the membrane. Cation membranes allow only cations (positively charged ions) to pass through; anion membranes allow only anions (negatively charged ions) to pass through. By alternately stacking these different membranes along with sufficient space to provide hydraulic channels, alternate concentrating and diluting channels can be created. The electric potential will cause any ionizable compound in the diluting cell to migrate into the concentrating cell. However, these selective membranes will not allow the ions to leave the concentrating cell.

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Advantages of electrodialysis are that the ions' solubility is the only concentration limit, the units can operate continuously without regeneration, the units are compact, and they operate using only one utility, a direct-current power source. The main disadvantage of electrodialysis is nonselectivity, which can allow impurities to migrate into the concentrate.

Reverse Osmosis

Reverse osmosis is a technology that uses pressure to force solutions through micro-porous membranes and allows the solutions to concentrate on one side of the membrane while the water is collected on the other. It is used by the electroplating industry to remove plating chemicals from rinse water as well as to purify wastewater for reuse.

Reverse osmosis separates the metal salts from the rinse solutions, yielding a concentrated metal solution suitable for recycling in the plating bath and water pure enough to be used for rinsing. These systems have relatively low capital costs, are continuous, compact, and easy to operate. Their main disadvantages are the plugging of the cells and precipitation when the concentrations become too high.

There are three types of reverse-osmosis membranes: tubular, spiral-wound, and hollow fiber. Tubular are the most expensive and space consuming. Spiral-wound and hollow fiber are competitive in terms of cost, with hollow fiber being more compact and spiral-wound having less tendency to plug. Again, careful consideration of all factors is mandatory before deciding on any of these units.

Electrolytic cell processes

Electrolytic cell processes differ from electrodialysis in that no membranes are used. In this process, metals from the rinse water are plated out by an electric current and deposited on a cathode. This process is also used to oxidize cyanide in cyanide plating rinses at the anode.

Generally, high-surface-area cathodes are used, with the metal being plated to an optimum thickness before removal. These cathodes are either sold to a metal reclaimer or the metal is stripped and reused.

Applications for electrolytic cell processing are being commercially used, and include:

- recovery of gold from both acid and alkaline plating rinse solutions
- removal of silver from cyanide and thiosulfate plating rinse solutions
- recovery of tin from plating rinse solutions following alkaline sulfite and fluoroborate plating
- removal of copper from plating rinse solutions following acid copper plating batches and copper from etch and pickling solutions

Ion exchange (Donnan dialysis)

Ion exchange technology relies on concentration gradients rather than pressure to transport species through ion-exchange resins. Typical uses for this process are water purification, deionization, recovery of substances from waste streams, and regeneration of process liquids.

Evaporation is the simplest recovery technology in terms of the principles involved.

By selecting the proper ion-exchange resins, undesirable ions are replaced by other ions that are not deleterious to the process. A good example of ion exchange is the typical water softener in which the highly insoluble calcium ions, responsible for water hardness, are replaced by highly soluble sodium ions.

This process is in widespread use and has been specifically adapted to many operations including the recovery of metal waste from electroplating processes. It is relatively inexpensive, fairly compact, and very efficient. However, periodic regeneration of the ion-exchange resin is required.

Coupled Transport Membranes

This process is based on the use of specifically constructed microporous membranes that are saturated with a water-immiscible organic solvent and encased in a support structure. When placed in a metal-ion water system, the solvent will form a complex with the metal ion at one interface. In response to the concentration gradient existing within the membrane, the complex will diffuse across the membrane and increase in concentration.

Ion-exchange technology is relatively inexpensive, fairly compact, and very efficient.

This is a relatively new process, having been in use for only a short time, and therefore no cost data or operating requirements are available. However, because of its relative simplicity (the process is driven by solution density), applications for its use appear favorable.