

# Cleaning Chemical Reduction in Metal Finishing

Dave Fister, retired, New York State Pollution  
Prevention Institute at Rochester Institute of  
Technology

# Outline

- ▶ Acid Bath Life Extension
- ▶ Caustic Cleaner Life Extension

Typical metal finishing line:  
Alkaline Cleaner → Acid Etch → Plating etc.

# Acid Life

Acid Life Extension involves increasing the usable life of an acid bath while reducing the amount of acid consumed

Key Benefits:

1. Reduction in amount of acid purchased
2. Reduction in amount of acid waste generated
3. Reduced risk of injury in handling acid and acid waste
4. Cost savings (in a wide array of areas - labor, material cost, disposal cost, lost revenue due to injuries and rework)
5. Increases process consistency

# Factors Degrading Acid Bath Life

- ▶ Acid is consumed (expended) as it dissolves metal in the etching process
- ▶ Acid is consumed by alkali dragged into the bath from previous cleaning tank rinses
- ▶ Acid dragout into acid rinse tanks
- ▶ Therefore, active acid goes down and dissolved metal and salts go up as the bath is used. **SLOWER ETCH RATE!**

# Acid Life Extension/Recovery

## For most mineral acids

There are many commercialized technologies available:

- ▶ Acid Sorption (ion exchange)
- ▶ Diffusion Dialysis (membrane osmosis)
- ▶ Electro-dialysis (membrane plus electrodes)
- ▶ Acid resistant nanofiltration membranes (pressurized membranes)
- ▶ Acid filtration using PRO-pHx (precipitation and filtration)

# Acid Sorption, Eco-Tec Inc. (now part of Koch Membranes)

- Technology is ion exchange.

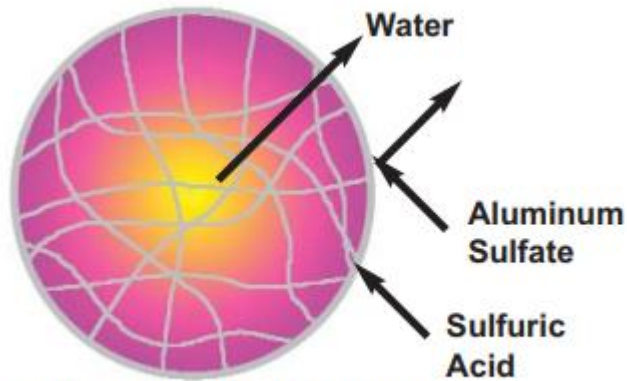


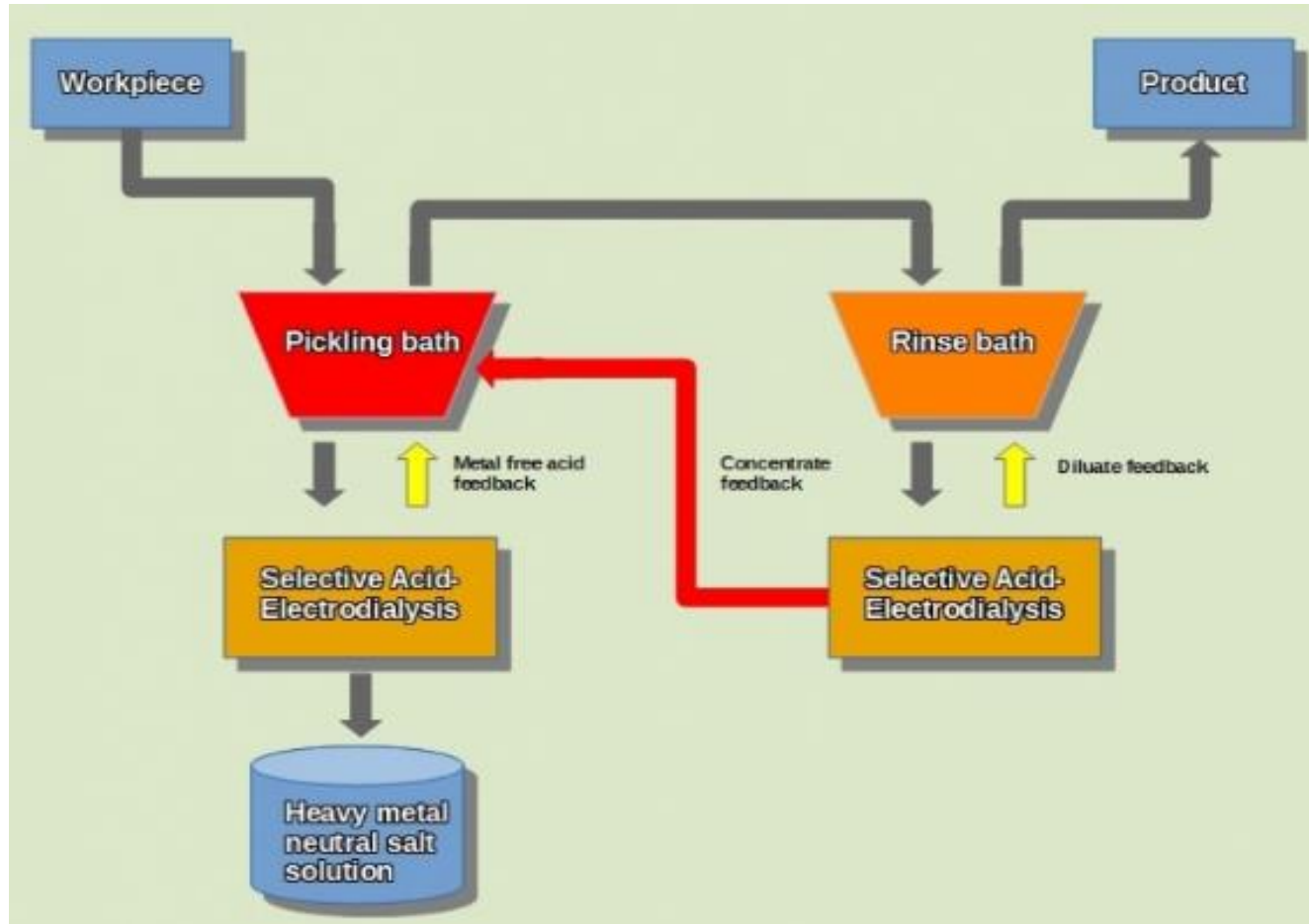
Figure 1: Eco-Tec APU® Resin

<https://www.kochseparation.com/technologies/ion-exchange/apu-acid-purification-unit>



Anopur for  
anodizing solution  
aluminum removal

# Electro-dialysis to recover acid

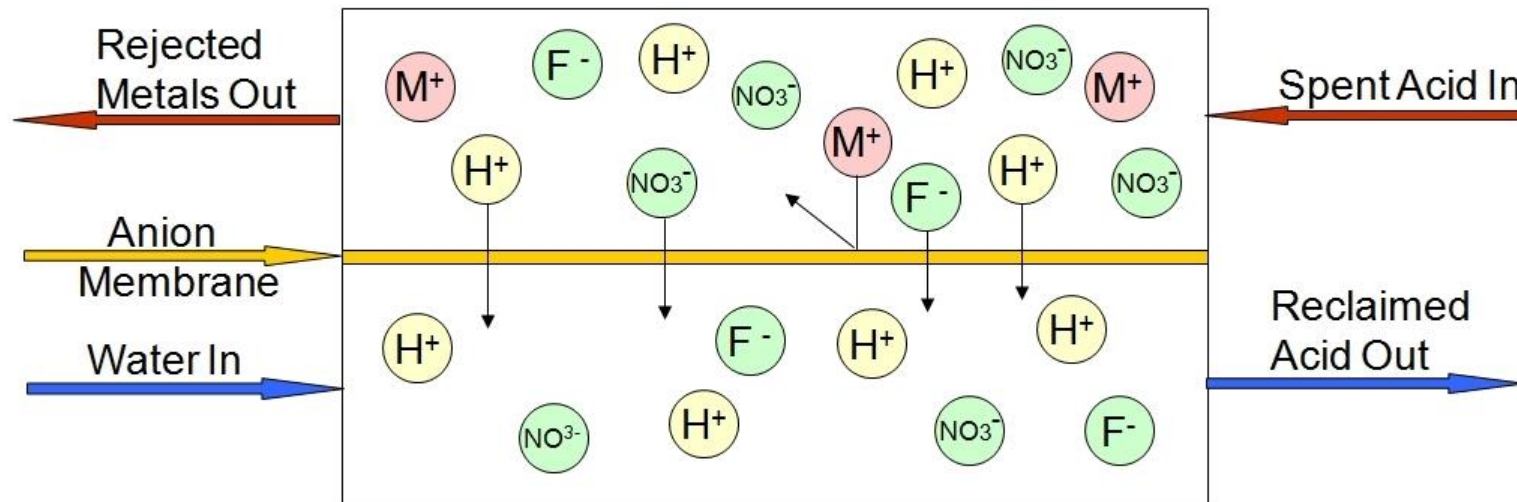


ED 1600, PC Cell

[https://www.pccell.de/en/Process-integrated-acid-recovery\\_34\\_Forschung.html](https://www.pccell.de/en/Process-integrated-acid-recovery_34_Forschung.html)

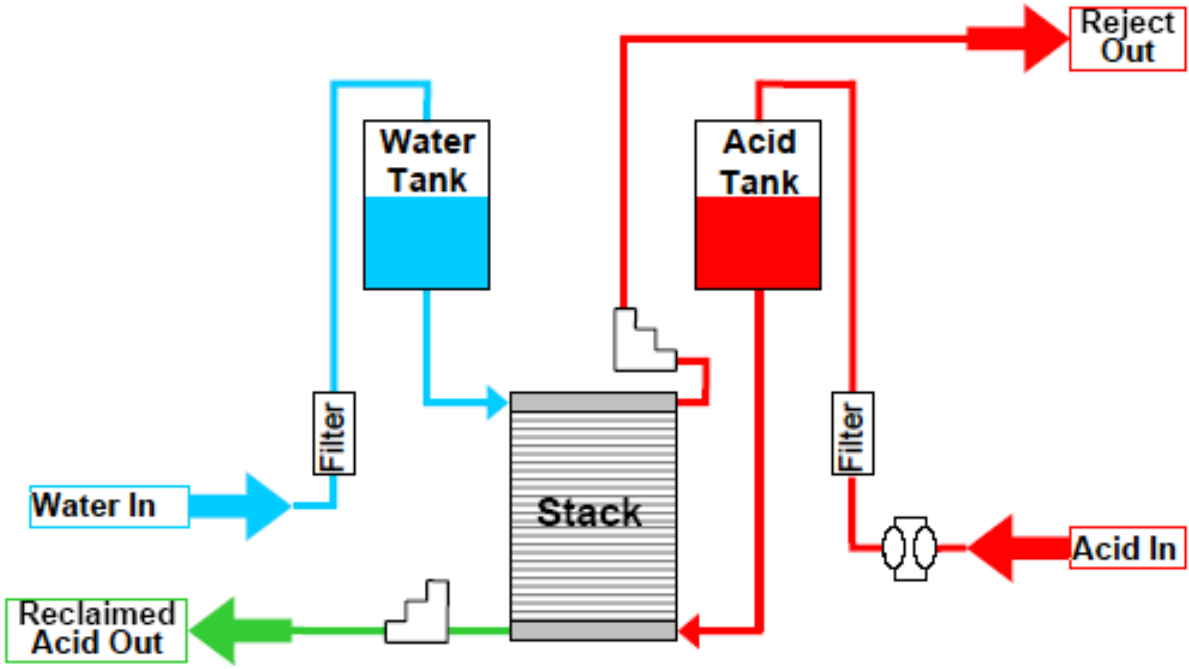
# Diffusion Dialysis Process

- ▶ Want to separate the dissolved metal from the acid
- ▶ Want to have a relatively high acid concentration at least close to that of the original acid, i.e. don't want a dilute acid stream





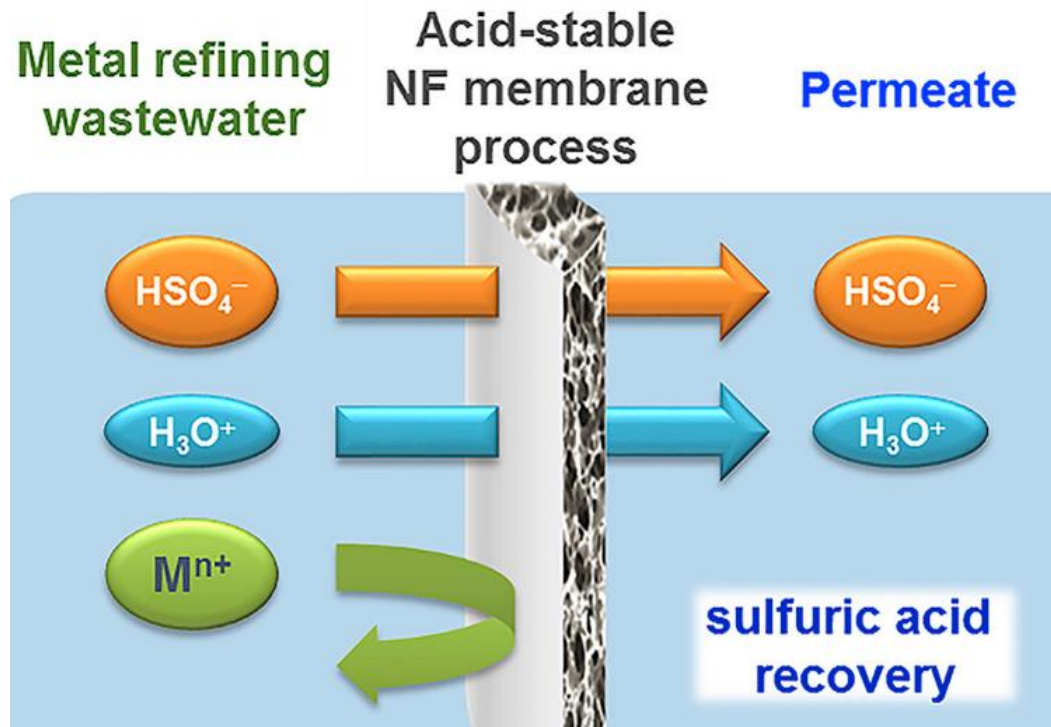
# Diffusion Dialysis:



Schematic and photo provided by Mech-Chem Associates, Inc.

# Nanofiltrration for acid recovery

- ▶ SelRO® MPS-34 - pH Stable Membrane, stable to 160°F, Koch Membranes



<https://www.sciencedirect.com/science/article/pii/S0301479718306005>

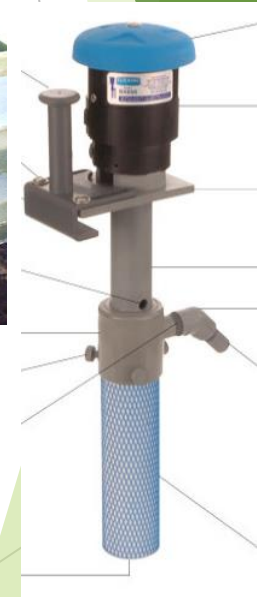
# Chemical Additive: PRO-pHx

“PRO-pHx is a proprietary blend of soluble silicates. It effectively immobilizes soluble metals by reacting with them to form insoluble metal silicates.

It will also react with volatile and non-volatile organic compounds to produce a non-volatile, non-toxic waste.

The organic and metallic precipitates are then easily filtered.”

Information provided by PRO-pHx, Inc.



# PRO-pHx precipitate on filter



## PRO-pHx successful in the following acids:

Phosphoric
Hydrochloric
Nitric
Sulfuric
Citric
Nitric + Ammonium Bi-fluoride
Sulfuric + Oxalic acid
Nitric + Phosphoric
Sulfuric + Phosphoric
Nitric + Hydrofluoric
Sulfuric + Hydrofluoric
Tri-acid combinations



# PRO-pHx case study

## Allbright Electropolishing, Inc., Clearwater, FL

Stainless steel electropolishing shop with 800 and 900 gallon polishing tanks

2002

- ▶ Large quantity generator, 33,000 lbs. of hazardous waste
- ▶ purchased \$23,000 of new acid
- ▶ decanted portion of each tank to reduce the dissolved metals load

2004

- ▶ started using PRO-pHx in both tanks
- ▶ 11,000 lbs. of hazardous waste, small quantity generator
- ▶ Purchased \$3,000 of new acid
- ▶ No more tank decanting

# Alkaline Cleaner Bath Life

- ▶ The cleaner chemical components are lost by:
  - ▶ Dragout to the rinse
  - ▶ Reaction with the organics (emulsification, chelation, etc.)
- ▶ The cleaner effectiveness degrades as the oil and dirt loading goes up with potential re-deposition of contaminants back onto the parts

## Cleaner Monitoring

- ▶ The chemical supplier should be able to provide test kits or test methods to monitor the cleaner chemistry
- ▶ Make cleaner chemistry additions based on the test results

# Cleaning the Cleaner

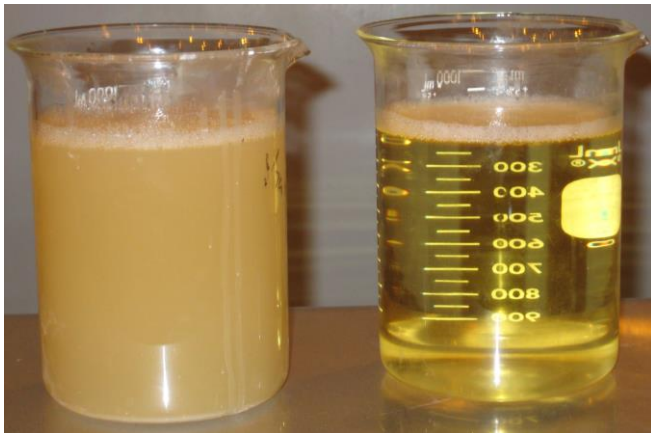
- ▶ Cooling a caustic cleaning bath sometimes causes the oils to come out of emulsion allowing oil to be skimmed off (weekend shutdowns). Not energy efficient!
- ▶ Continuous in-tank filtration can usually remove suspended solids (typical polymer filters cannot tolerate solution temperatures >120° F so temperature limitations)
- ▶ In-tank spargers and weirs can help remove surface oils
- ▶ High temperature, high pH tolerant metal or ceramic ultrafiltration can remove colloidal solids and emulsified oils, in most cases while retaining much of the cleaning chemistry



# TiO<sub>2</sub>/SS Material Micro-Ultrafiltration

## Arbortech equipment

- ▶ Filter able to remove solids and oil emulsions from a cleaner at 200°F, minimal temperature limitations
- ▶ pH of 1-14, no pH limitations



Washer Washer Pro  
series, Arbortech

# Arbortech Case Study

## Midwest Engine Manufacturer

- ▶ Reduced cleaner tank dump frequency from 2 weeks to over 5 weeks
- ▶ Saved on cleaning chemistry
- ▶ Improved part cleaning consistency so less rework

# Case Study Economics

## Chromate/E-Coat Paint Line - Midwest Engine Manufacturer

### 2005 Costs



### Client Documented Savings



### R.O.I.

R.O.I. = Costs of Implementation/Benefits

R.O.I. = \$45,592/\$45,010

R.O.I. = 1.01 years