**Cal Poly MatE**

**Common Metallographic Etchants**

**Common Metallographic Etchants**

This book contains information on the most commonly used metallographic etchants. If the etchant you desire is not found within this book, please consult the **ASM Handbook** (which can be found online in the Kennedy Library database).

**General Notes About Etching**

* All etchants described herein are **extremely corrosive**. Gloves, apron, splash goggles, long pants and closed toed shoes are required for etching.
* MSDS are available above the chemical storage cabinet in the etching room, and should be read before working with unfamiliar chemicals.
* Always measure and mix chemicals at arm’s length inside fume hood.
* When measuring chemicals, ensure any measuring vessel is clean and dry of other residue.
* When mixing acids, always add acid to water.
* Use appropriate measuring and mixing vessels.
  + Hydrofluoric acid can etch through glass, always measure, mix and store in HDPE vessels.
* Always dispose of chemicals in appropriate disposal vessel. If unsure which vessel to dispose in, receive confirmation before disposal.

**For Chemical Safety and Disposal Information Contact:**

Tom Featherstone

Chemical Hygiene Specialist  
Building 80, Room 103  
Telephone: (805) 756-6661  
Fax: (805) 756-1602[tfeather@calpoly.edu](mailto:tfeather@calpoly.edu)

FORGENG SOLUTIONll lllllllllllllllllllllllllllllllllllllllll

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| Lubricant: | Components: | Amounts: | Application: | Notes: |
| For 6μm, 3μm, 1μm, and 0.5μm polishing pads | Distilled Water  Ethylene Glycol  Ethanol | 2400ml (80%)  300ml (10%)  300ml (10%) | Spray 1-2 times on polishing pads as needed | Store in plastic spray bottle |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves) as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before mixing.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing

* Mix all chemicals under fume hood.
* Do not mix ethylene glycol and ethanol before adding to water. Add each chemical separately to water (in either order).

Clean -up

* Transfer prepared Forgeng Solution into pre-existing spray bottle.
* Wash all graduated cylinders and mixing utensils when finished.

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| ALUMINUM ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Keller’s Etch | Distilled water  Nitric Acid  Hydrochloric Acid  Hydrofluoric Acid | 190 ml  5 ml  3 ml  2 ml | Immerse 10-30 sec | Use Fresh |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

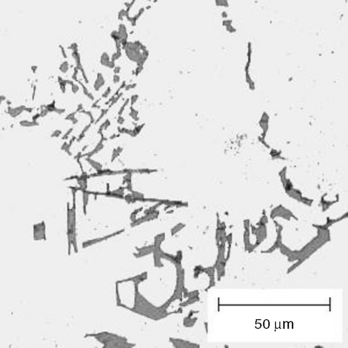
* Always mix acid into water!
* Hydrofluoric acid attacks glass! HDPE vessels should be used for measuring, etching and storage.

Etching Sample

* Immerse sample for 10 – 30 seconds.
* Use fresh etchant!

Clean -up

* Dispose of etchant in acid waste container.



Unmodified as-cast A356 etched in Keller's Reagent[1]

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| ALUMINUM ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| General Purpose Al Etch | Distilled water  Hydrofluoric Acid | 90-100ml  .1-10 ml | Immerse 10-30 sec | Very Common Al Etch |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

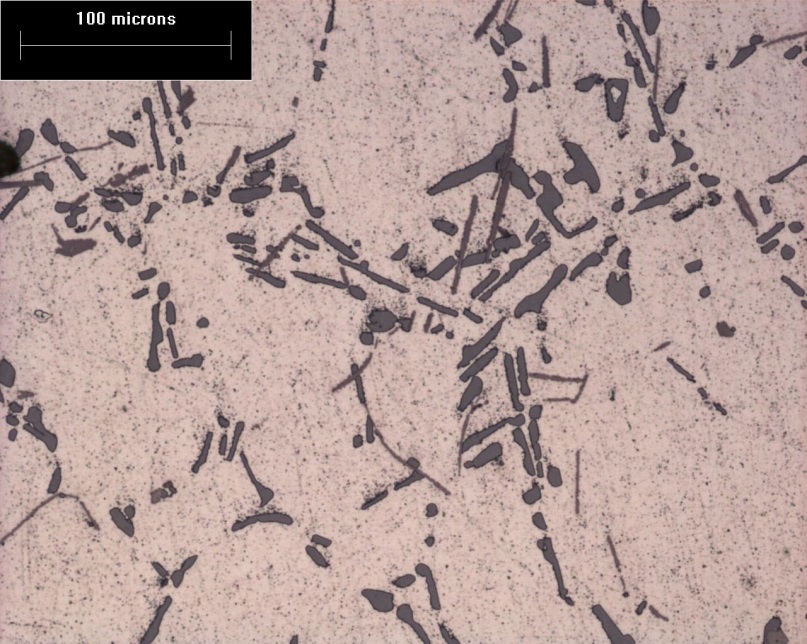
* Always mix acid into water!
* Hydrofluoric acid attacks glass! HDPE vessels should be used for measuring, etching and storage.

Etching Sample

* Immerse sample for 10 – 30 seconds.

Clean -up

* Dispose of etchant in acid waste container.

Aluminum Alloy A356-T6 etched 30 sec in 1% HF.

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| ALUMINUM ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Kroll's Reagent | Distilled water  Nitric Acid  Hydrofluoric Acid | 92 ml  6 ml  2 ml | Immerse 10-15 sec | For Cu-Al Alloys |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Always mix acid into water!
* Hydroflouric acid attacks glass! HDPE vessels should be used for measuring, etching and storage.

Etching Sample

* Immerse sample for 10 – 15 seconds.

Clean -up

* Dispose of etchant in acid waste container.

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| COBALT ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| General Cobalt Etch | Ethanol  Hydrofluoric Acid  Nitric Acid | 200 ml  7.5 ml  2.5 ml | Immerse 2-4 min | For Cobalt and Cobalt Alloys |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Always mix acid into ethanol!
* Hydroflouric acid attacks glass! HDPE vessels should be used for measuring, etching and storage.

Etching Sample

* Immerse sample for 2 – 4 Minutes.

Clean -up

* Dispose of etchant in acid waste container.

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| COPPER ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Macro Copper Etchant | Distilled water  Nitric Acid | 50 ml  50 ml | Immerse 5-120 sec | Reveals Grain Boundaries and Cracks in Copper, Brasses, and Aluminum Bronze |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Always mix acid into water!

Etching Sample

* Immerse sample for 5 – 120 seconds.

Clean -up

* Dispose of etchant in acid waste container.

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| COPPER ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Copper and Copper Alloys | Ammonium Hydroxide  Distilled Water  Hydrogen Peroxide (3%) | 25 ml  25 ml  25-50 ml | Swab 15-45 seconds | Use Fresh, add Peroxide last |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

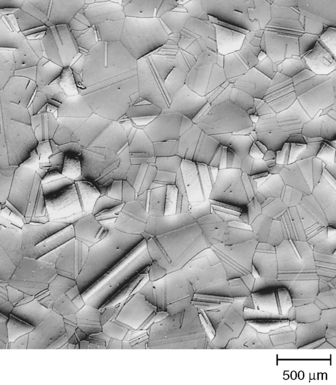
* Mix Ammonium Hydroxide into water, thoroughly mix, add peroxide last.

Etching Sample

* Swab sample for 15 – 45 seconds.
* Use fresh etchant!

Clean -up

* Dispose of etchant in alkaline waste container.



Annealed Cartridge Brass.[2]

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| COPPER ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Kroll's Reagent | Distilled Water  Hydrofluoric Acid  Nitric Acid | 92 ml  2 ml  6 ml | Immerse 10-15 seconds | For Cu-Al Alloys |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Mix Nitric Acid into water, then add Hydrofluoric Acid.
* Hydroflouric acid attacks glass! HDPE vessels should be used for measuring, etching and storage.

Etching Sample

* Immerse sample for 10 – 15 seconds.

Clean -up

* Dispose of etchant in acid waste container.

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| IRON ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Nital | Ethanol  Nitric Acid | 100 ml  1-10 ml | Immerse 5-120 sec | For Cast Iron, Carbon Steel, Low Alloy Steel |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

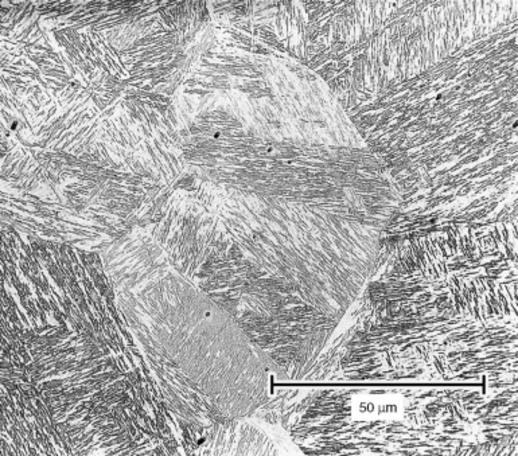
* Always mix acid into Ethanol!
* Do Not Exceed 10 ml Nitric Acid - EXPLOSIVE!

Etching Sample

* Immerse sample for 10 – 120 seconds.

Clean -up

* Dispose of etchant in acid waste container.



Water quenched low alloy steel etched in 2% Nital.[3]

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| IRON ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Glyceregia | Hydrochloric Acid  Glycerol  Nitric Acid | 15 ml  10 ml  5 ml | Swab | For Stainless Steels Reveals Grain Boundaries and Cracks |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

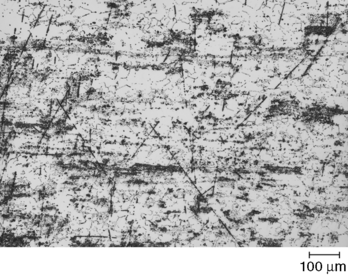
* Thoroughly mix Hydrochloric Acid and Glycerol, then add Nitric Acid

Etching Sample

* Swab sample.

Clean -up

* DO NOT dispose of in waste container. May produce Nitroglycerine or Nitrosyl Chloride in presence of Sulphuric Acid!
* Place in labeled HDPE bottle in fume hood and contact Tom Featherstone for disposal. (805) 756-6661 (contact before mixing)

Duplex Stainless Steel etched in Glyceregia.[4]

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| IRON ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Acetic Glyceregia | Hydrochloric Acid  Acetic Acid  Nitric Acid  Glycerol | 15 ml  10 ml  5 ml  2 drops | Swab | For High Alloy Stainless Steels. Reveals Grain Boundaries and Cracks |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Thoroughly mix Hydrochloric Acid, Acetic Acid and Glycerol, then add Nitric Acid

Etching Sample

* Swab sample.

Clean -up

* DO NOT dispose of in waste container. May produce Nitroglycerine or Nitrosyl Chloride in presence of Sulphuric Acid!
* Place in labeled HDPE bottle in fume hood and contact Tom Featherstone for disposal. (805) 756-6661 (contact before mixing)

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Nitro Hydrochloric Acid | Hydrochloric Acid  Nitric Acid | 40 ml  10 ml | Immerse in **hot** etchant up to 5 minutes | For High Alloy Steels |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Begin with Hydrochloric Acid, then add Nitric Acid.

Etching Sample

* Immerse sample hot etchant for up to 5 minutes.
* Will fume!
* Use immediately after mixing!

Clean -up

* Do not store.
* Dispose of etchant in acid waste container.

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| NICKEL ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Glyceregia | Hydrochloric Acid  Glycerol  Nitric Acid | 15 ml  10 ml  5 ml | Swab 5-60 seconds | For Ni Alloys Reveals Grain Boundaries and Cracks |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

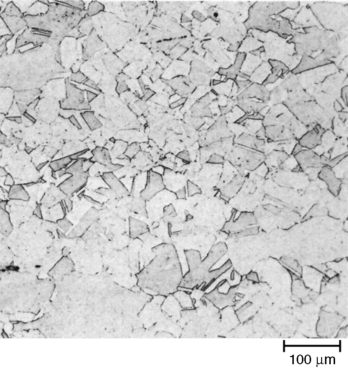
* Thoroughly mix Hydrochloric Acid and Glycerol, then add Nitric Acid

Etching Sample

* Swab sample for 5 – 60 seconds.

Clean -up

* DO NOT dispose of in waste container. May produce Nitroglycerine or Nitrosyl Chloride in presence of Sulphuric Acid!
* Place in labeled HDPE bottle in fume hood and contact Tom Featherstone for disposal. (805) 756-6661 (contact before mixing)



Hot rolled Monel K-500 etched in Glyceregia.[5]

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| NICKEL ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Modified Glyceregia | Glycerol  Hydrochloric Acid  Nitric Acid | 60 ml  50 ml  10 ml | Swab 10-60 seconds | For High-Nickel Superalloys  Reveals Precipitates. |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Thoroughly mix Hydrochloric Acid and Glycerol, then add Nitric Acid

Etching Sample

* Swab sample for 10 – 60 seconds.

Clean -up

* Do not store, and discard when solution turns yellow.
* DO NOT dispose of in waste container. May produce Nitroglycerine or Nitrosyl Chloride in presence of Sulphuric Acid.
* Place in labeled HDPE bottle in fume hood and contact Tom Featherstone for disposal. (805) 756-6661 (contact before mixing)

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| NOBLE ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Silver Etch | Ammonium Hydroxide  Hydrogen Peroxide (3%) | 25 ml  10 ml | Swab up to 60 seconds. | For Sterling Silver, use 50:50 mix. |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Mix Ammonium Hydroxide and Hydrogen Peroxide

Etching Sample

* Swab sample for up to 60 seconds.

Clean -up

* Discard after use
* Dispose of etchant in alkaline waste container.

NOBLE ALLOYS lllllllllllllllllllllllllllllllllllllllllll

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Aqua Regia | Hydrochloric Acid  Nitric Acid | 25 ml (30 ml for pure Au)  25 ml (10 ml for pure Au) | Immerse up to 60 seconds | For High Noble Alloys |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etching

* Begin with Hydrochloric Acid, add Nitric Acid.

Etching Sample

* Immerse sample in etchant for up to 60 seconds.
* Use fresh etchant!
* Will Fume!

Clean -up

* Dispose of etchant in acid waste container.

NOBLE ALLOYS lllllllllllllllllllllllllllllllllllllllllll

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Platinum Etch | Distilled Water  Hydrochloric Acid  Nitric Acid | 30 ml  25 ml  5 ml | Immerse in **hot** etchant up to 5 minutes |  |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Etching

* Mix Hydrochloric acid into distilled water first, then add Nitric Acid.

Etching Sample

* Immerse sample hot etchant for up to 5 minutes.

Clean -up

* Dispose of etchant in acid waste container.

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| REFRACTORY ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Kroll's Reagent | Distilled Water  Hydrofluoric Acid  Nitric Acid | 100 ml  1-3 ml  2-6 ml | Swab or Immerse 3-30 seconds | For Titanium Alloys |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Mix Nitric Acid into water, then add Hydrofluoric Acid.
* Hydroflouric acid attacks glass! HDPE vessels should be used for measuring, etching and storage.

Etching Sample

* Immerse sample for 3 – 30 seconds.

Clean -up

* Dispose of etchant in acid waste container.

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#### Ti-6Al-4V, as-forged, Kroll's Reagent.[6]

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| REFRACTORY ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Titanium and Zirconium Etch | Distilled Water  Hydrofluoric Acid | 200 ml  1 ml | Swab or Immerse | Higher concentrations may be used, may stain |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Always mix acid into water!
* Hydroflouric acid attacks glass! HDPE vessels should be used for measuring, etching and storage.

Etching Sample

* Immerse or swab sample.

Clean -up

* Dispose of etchant in acid waste container.

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| REFRACTORY ALLOYS |

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| DuPont Niobium Reagent | Distilled Water  Sulphuric Acid  Nitric Acid | 50 ml  14 ml  5 ml | Immerse |  |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Always mix acid into water!

Etching Sample

* Immerse sample.

Clean -up

* Dispose of etchant in acid waste container.

SINTERED CARBIDESllllllllllllllllllllllllll lllllllllllllllll

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| Etchant: | Components: | Amounts: | Application: | Notes: |
| Carbide Etch | Distilled Water  Nitric Acid | 97 ml  3 ml | Immerse in **boiling** etch up to 60 seconds | Reveals WC, Mo2C, and TiC |

Preparation

* Make sure you have the proper attire (i.e., safety goggles, long pants, close-toe shoes, apron, and gloves), as well as proper set-up and clean-up items (graduated cylinder, storage vessels, petri dish, etc.) before starting.
* Ensure measuring vessels are clean and dry of water or any other residue.

Mixing Etchant

* Always mix acid into water!

Etching Sample

* Immerse sample in **boiling** etchant for up to 60 seconds.

Clean -up

* Dispose of etchant in acid waste container.

**References**

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3. B.L. Bramfitt and S.J. Lawrence, Metallography and Microstructures of Carbon and Low-Alloy Steels, *Metallography and Microstructures,* Vol 9, *ASM Handbook*, ASM International, 2004, p. 608–626
4. G.F. Vander Voort, G.M. Lucas, and E.P. Manilova, Metallography and Microstructures of Stainless Steels and Maraging Steels, *Metallography and Microstructures,* Vol 9, *ASM Handbook*, ASM International, 2004, p. 670–700
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6. L.M. Gammon, R.D. Briggs, J.M. Packard, K.W. Batson, R. Boyer, C.W. Domby, Metallography and Microstructures of Titanium and Its Alloys, *Metallography and Microstructures,* Vol 9, *ASM Handbook*, ASM International, 2004, p. 899–917

**These and many more etchants may be found in the ASM Handbook from ASM International**