Etchants for Iron and Steel

**Nital**
1-10 mL HNO₃
90-99 mL ethanol or methanol

Most common etchant for Fe, carbon and alloy steels, cast irons. Reveals alpha grain boundaries and constituents. The 2% solution is the most common. Use by immersion for up to 60 seconds or by swabbing. Do not store ethanolic solutions that exceed 2% nitric acid. The 5-10% solution is used for high-alloy steels, should not be stored if made with ethanol. (Boyson)

**Picro**
4g picric acid
100 mL ethanol

Recommended for structures consisting of ferrite and carbides. Does not reveal ferrite grain boundaries. Addition of 0.5-1% naphthol blue (a commonly used antibacterial agent) improves etch rate and uniformity. Use by immersion for up to 60 seconds or by swabbing. (Kgevski)

**Glycerol**
3 parts HNO₃
2 parts glycerol
1 part H₂O

For high alloy steels, austenitic Mn steels, stainless steels and Ni-based alloys. Reveals grain structure, outlines sigma and carbides. Use fresh. Discard when turns yellow/orange. Do not store. For slower action and martensitic or ferrite stainless steel, use 2 parts HCl. Swab sample 5-30 seconds.

**Vitelito’s Reagent**
1g picric acid
5 mL HCl
100 mL ethanol

For high alloy steels and stainless steels. Use at 20°C for up to 1 minute by immersion or swabbing. Outlines constituents such as carbides, sigma phase, and delta ferrite; etches martensite.

**Etchants for Copper and Alloys**

**25 mL NH₄OH**
25 mL distilled water (optional)
25-50 mL H₂O₂ (3%)

General purpose grain contrast etch for Cu and alloys (does not always produce grain contrast.) Use fresh, add peroxide last. Use under a fume hood. Swab sample 5-45 seconds.

**5g Fe(NO₃)₃**
25 mL HCl
70 mL distilled water

Excellent general purpose etch, reveals grain boundaries well. Immerse sample 10-30 seconds. (Stepan and Prohaska)

**Etchants for Aluminum and Alloys**

0.1-10 mL HF
90-100 mL distilled water

General purpose reagent. Attacks FeAl₆, other constituents outlined. Grain contrast usually poor. The 0.5% concentration of HF is very popular. Use by swabbing.

**Keller’s Reagent**
2.5 mL HNO₃
1.5 mL HCl
1 mL HF
95 mL distilled water


**Etchants for Nickel and Alloys**

**Kalling’s No. 2**
2g CuCl₂
40 mL HCl
40-80 mL ethanol

“Waterless Kalling’s” for Ni-Cu, superalloys and stainless steels. Good for grain size. Swab for up to a few minutes. Can be stored.

**Acetic Glycerol**
15 mL HCl
10 mL acetic acid
5 mL HNO₃
1-2 drops glycerol (optional)

For superalloys. Use fresh. Discard when turns yellow/orange. Do not store. Swab sample 5-30 seconds.

**Etchants for Titanium and Alloys**

**Kroll’s Reagent**
1-3 mL HF
2-6 mL HNO₃
100 mL distilled water

Very good etch. Swab sample 3-10 seconds or immerse sample 10-30 seconds.

**Etchants for Titanium and Alloys**

**Etchants for Nickel and Alloys**

**Etchants for Copper and Alloys**

**Etchants for Aluminum and Alloys**

**Etchants for Iron and Steel**

**Etch Rate and Uniformity.**

Etch rates and uniformity are critical in metallographic analysis. The table provides a guide to the etch rates and uniformity of various etchants.

**Etch Table**

1. All etchants when water is specified, distilled water should be used. Reagent-grade chemical, acids, bases, solvents, etc. should be used for best results. Use fume hoods, goggles, gloves and any other equipment to ensure proper lab safety. Particular care should be used when working with HF, as it is a very strong chemical. For those unfamiliar with safe laboratory procedures, testing is highly recommended.