

Etchants for microscopic examination of carbon and alloy steels

Number	Etchant	Purpose or characteristic revealed
1	Nital: 1 to 5 ml HNO ₃ in 99 to ml ethanol (95%) or methanol (99%)	Develops ferrite grain boundaries in low-carbon steels; produces contrast between pearlite and a cementite or ferrite network; develops ferrite boundaries in structures consisting of martensite and ferrite; etches chromium-bearing low-alloy steels resistant to action of picral. Preferred for martensitic structures.
2	Picral: 4 g picric acid in 100 ml ethanol (95%) or methanol (95%)	Reveals maximum detail in pearlite, spheroidized carbide structures, and bainite; reveals undissolved carbide particles in martensite; differentiates ferrite, martensite, and massive carbide by coloration; differentiates bainite and fine pearlite; reveals carbide particles in grain boundaries of low-carbon steel. Addition of about 0.5 to 1 ml zephiran chloride wetting agent increases speed of attack.
3	Vilella's reagent: 5 ml HCl, 1 g picric acid, 100 ml ethanol (95%) or methanol (95%)	For contrast etching (a); may reveal prior austenite grains in tempered martensite and in austempered steels; reveals pearlite colonies.
4	1 to 1.5 ml HCl (conc); 2 to 4 g picric acid; 100 ml ethanol (95%)	Reveals pearlite colonies (b).
5	30 g K ₂ Cr ₂ O ₇ in 225 ml hot distilled water; and 30 ml acetic acid (glacial)	Reveals lead inclusions, causing them to appear yellow or gold when specimen is examined under polarized light (c).
6	16 g CrO ₃ in 145 ml distilled water; add 80 g NaOH (d)	Reveals intergranular oxidation due to overheating prior to hot working (e).
7	10 g potassium metabisulfite, 100 ml water	For resolution of hardened structures. Should be preceded by an etch in nital or picral.
8	Howarth's reagent: 10 ml H ₂ SO ₄ , 10 ml HNO ₃ , 80 ml water	For detection of overheating and burning, and for examination of steel forgings
9	8 g sodium metabisulfite in 100 ml water	Produces good contrast in as-quenched martensitic structures.

10	1 g KCN in 100 ml water, mixed with 0.25 g diphenylthiocarbazone in 10 ml chloroform	Reveals lead inclusions by coloring them red; coloration is most visible when specimens are viewed under polarized light.
11	Saturated aqueous picric acid plus 1 g/100 ml sodium tridecylbenzenesulfonate	Most successful etch for revealing prior austenite grain boundaries in medium- or high-carbon martensitic steels. Steels should be untempered, or tempered below 540°C (1000°F). Immerse or swab for up to 20 min.
12	2 g picric acid, 25g sodium hydroxide, 100 ml water	Alkaline sodium picrate. Use boiling for 30 seconds or more to darken cementite. Solution will attack mounts made from Bakelite.
13	50 ml cold saturated aqueous sodium thiosulfate, 1 g potassium metabisulfite	Klemm's tint etch; color ferrite. Immerse for 40 to 100 s until surface is colored. A light pre-etch with nital or picral improves sharpness.

- (a) Specimen should be temperature for 20 to 30 min at 315°C (600°F).
- (b) Immerse specimen for 5 to 10 seconds in solution at room temperature.
- (c) Etch for 10 to 20 seconds in solutions at room temperature, rinse in hot water and dry.
- (d) Sodium hydroxide (NaOH) must be added slowly, with constant stirring.
- (e) Immerse specimen in boiling solution for 10 to 30 min, rinse in hot water, dry in air blast.

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