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Improvement in Optical Characterization on Ultra-Low Carbon Steels

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Ultra-low carbon steels are one of the main materials used in automotive applications, due to their high formability and good mechanical properties [1,2]. On the other hand, optical characterization in this kind of steel appears to be repetitive, where the main chemical etching used tends to be Nital (combination of nitric acid (HNO_3) and ethyl alcohol (C_2H_6O)) [3]. In this way, it is important to realize investigation in this knowledge field, where one of the most promised alternatives appears to be the combination of common techniques and the so-called "color etchings" [4,5]. This document analyzes the microstructure in ultra-low carbon steel for deep stamping purposes, using different chemical etchings to improve the quality image obtained by optical microscopy characterization. For this purpose, it was applied the chemical etching Nital 5% (HNO_3+ C_2H_6O), followed by sodium metabisulfite ($Na_2S_2O_5$).

Table 1. Chemical composition of the ultra-low carbon steel.

Element	C	Mn	P	S	Si	Fe
wt%	0.002	1.540	0.038	0.004	0.320	Balance

In the beginning, all samples were polished until 1 μm diamond paste, followed by chemical etching as shown in Table 2. Finally, the immersion technique was used to produce a homogeneous distribution of the chemical etching on all the surfaces.

Table 2. Chemical etchings used.

Chemical etching name	Composition	Concentration	Time
Nital 5%	$HNO_3 + C_2H_6O$	5% HNO_3 + 95% C_2H_6O	30 s
Sodium metabisulfite solution	$Na_2S_2O_5$ + Distilled H_2O	1 gr $Na_2S_2O_5$ + 40 ml Distilled H_2O	25-35 min

Fig. 1 shows the evolution of the microstructure in the ultra-low carbon steel after different times immersed in the sodium metabisulfite solution. It is possible to observe from figures 1a-e a significant improvement in the quality image of the optical micrographs, related to the increment in time of the sodium metabisulfite solution.

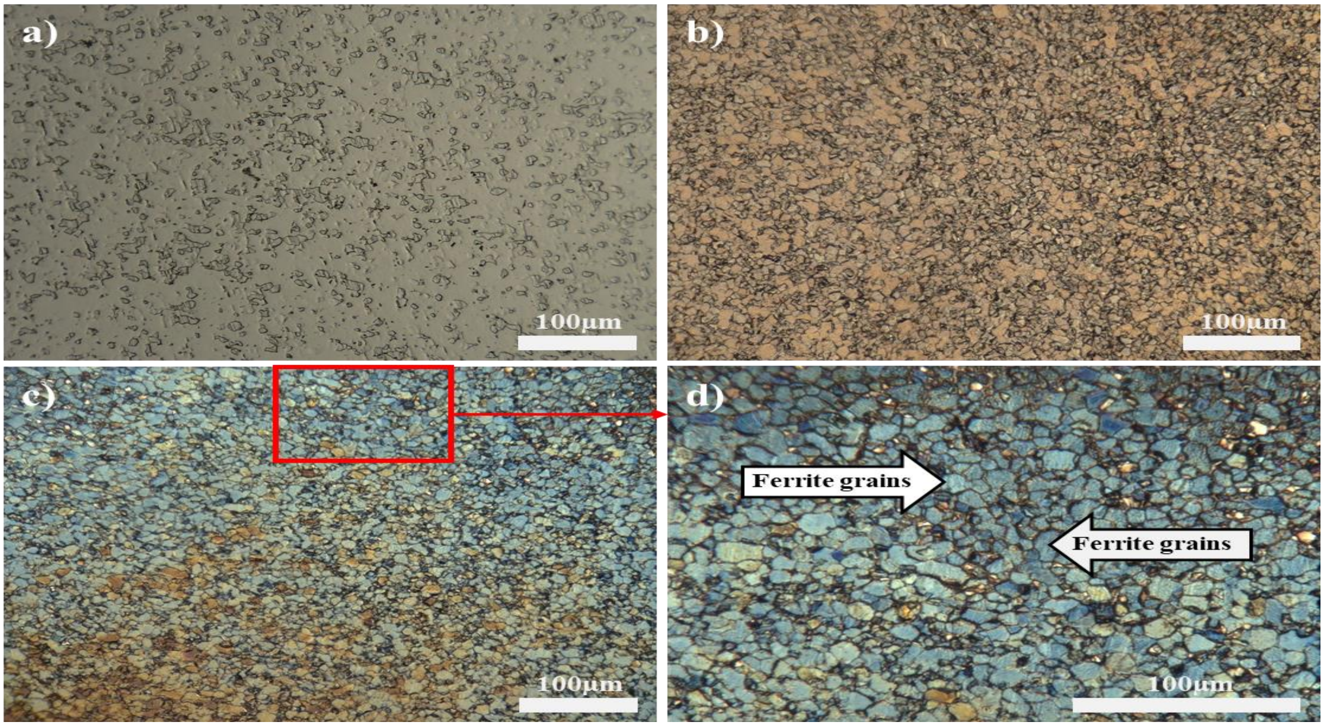

Figure 1. Bright field of optical micrographs at 500x and 1000x, after different times of immersion in the sodium metabisulfite solution. (a) non-immersion, (b) 25 min, (c, d) 35 min.

Results show that in Fig. 1a, ferrite grains boundaries are not clearly identified due to the difficult control of the parameters related to the chemical acid used (Nital 5%), it is evident that many parameters such as time to etch, chemical concentration, and a correct technique used to reveal the microstructure in some steels are not always easy to control, as can be seen in Fig. 1a. On the other hand, Figs. 1b-d, show a good quality image, where is possible to see ferrite grains boundaries clearly. Also, it is evident a change in tonality in the pictures, depending on the time immersed in the sodium metabisulfite solution that change from brown to blue color. It is important to mention, that only bright field technique was used in optical microscopy equipment, showing facilities to improve a good quality image in one of the most common apparatus used on microscopy labs, and making an important contribution in this knowledge field.

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