

# Oxidation-reduction effects on copper colour in glasses and glazes

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In glasses or ceramic glazes, copper can either produce a blue to green colour, or form a vivid red known as “pigeon-blood” or “liver red”, due to the formation of copper-rich nanoparticles. Understanding the mechanisms for these colourations can help control colour formation, but also reveal ancient manufacturing processes, in medieval stained glasses for instance.

On the one hand, blue to green hues obtained with cupric ions largely depend on the glass composition and heat treatment. The reason for the colour variation was investigated through EPR spectroscopy and optical absorption spectroscopy. It could be shown that redox effect alone can not account for hue variations. The research pointed towards an effect linked to inter-valence charge transfers, varying with  $\text{Cu}^{2+}/\text{Cu}^+$  equilibrium and with copper concentration.

On the other hand, reductive atmosphere during firing can lead to the formation of copper-rich nanoparticles. Both  $\text{Cu}_{(0)}$  and  $\text{Cu}_2\text{O}$  nano-crystals can lead to a red hue, which makes the origin of the colour controversial. We present the PhD research project aiming at understanding the mechanisms of colour formation through *in situ* XAS, optical absorption spectroscopy, and electronic imaging, during the development of colour.



Figure 1: “Pigeon-blood” porcelain glaze by France Franck [1].

## References

[1] – Ph. Sciau, L.Noé, Ph. Colomban, *Ceramic International* 42 (2016) 15349-15357.