Cellulose and lignin nano-based consolidant for waterlogged archaeological wood

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The Italian standard UNI 11206:2007 (Beni culturali – Legno di interesse archeologico ed archeobotanico – Linee guida per il recupero e prima conservazione) defines waterlogged archaeological wood as: "wood with a moisture content higher than the cell wall saturation point". This wood comes from submerged archaeological sites (in lake, sea, river or wetland) or from land waterlogged sites. Generally, waterlogged wooden artefacts preserve their original size and shape but often they have underwent severe cell wall decay due to chemical and biological factors. The pH, the salinity of water permeating the sediments and the chemical nature of sediment (Hedges 1990) together with the action of biological degraders (e.g. erosion and tunnelling bacteria and soft rot fungi) (Björdal et al. 1999) affect the wood causing a more or less sever mass loss and an increase of porosity and permeability that lead to a spongy and weakened material.

Drying waterlogged archaeological artefacts is necessary for musalization but it is always a high risk procedure because it could cause severe shrinkages and collapses. So, the conservation practices focus not only on removing water from wood, but also on substitute it with materials able to consolidate the degraded cell walls with the two main aims of stabilise shape, size and proportion of the artefact and enable it to withstand the future preservation environment (Grattan and Clarke). By now, the most used consolidants are polymers (e.g. PEG), sugars (e.g. lactitol) or resins (e.g. Kauramin) (Christensen et al. 2012; Imazu & Morgòs 1997; Unger et al. 2001). The present work aimed to test three cellulose and lignin nano-based consolidants: lignin nanoparticles (LNPs) obtained form beech wood *via* a non-solvent method involving dialysis (Zikeli et al. 2018); CelluForce NCC®, cellulose nanocrystals chemically extracted from native cellulose; bacterial nanocellulose (BNC) obtained from cultures fed with agro-alimentary waste.

Waterlogged archaeological wood samples of different species (oak, elm, pine and fir) were selected for the tests. The wood decay was assessed through physical measurements (maximum water content, basic density, residual basic density) before the consolidation procedure. The efficacy of the treatments was evaluated in term of equilibrium moisture content (EMC) and Anti-Shrink Efficiency (ASE).