Title: Time optimized genipin chitosan aerogels for catalytic applications

Astha Vishwakarma[a] , Benjamin Carbonnier[a], Samia Mahouche-Chergui[a]

[a]Institut de Chimie et des Matériaux Paris-Est (ICMPE), Centre National de la Recherche Scientifique (CNRS), Universite Paris-Est Creteil, UMR 7182, 2 Rue Henri Dunant, 94320 Thiais, France

Introduction: Natural polymer-based aerogels are gaining prominence as functional catalytic supports in green chemistry. Chitosan crosslinked with genipin forms robust, biodegradable aerogels with tunable surface functionalities and porous structures. In this work, the effect of crosslinking time on the catalytic efficiency and structural properties of chitosan-genipin aerogels is systematically explored.

Methods: Genipin-chitosan aerogels (2.4% w/v chitosan, 1.67% genipin) were prepared with controlled crosslinking times (4, 8, 24, 72 hours) before freeze-drying. Catalytic performance was evaluated using model reactions, while structural evolution was monitored via XRD, SEM, and mechanical testing. Mechanical properties were evaluated using a universal testing machine (Instron 5567, USA) in accordance with ASTM D1621. Repair/healing capability of these materials were analysed and self-healing efficiency was quantified through fracture-repair cycles using water-mediated healing protocols.

Results: Crosslinking time profoundly influenced both catalytic and self-healing properties. Short crosslinking (4-8 hours) preserved 62% self-healing efficiency while maintaining accessible porosity (32-24%) ideal for catalytic applications. Extended crosslinking (24-72 hours) enhanced mechanical strength (2.1-2.4 MPa) but eliminated self-healing capability. Thermal stability improved with crosslinking duration, with main degradation shifting from 274°C to higher temperatures.

Conclusions: Crosslinking time serves as a critical parameter in designing bio-based catalytic systems. This study demonstrates how genipin-crosslinked chitosan aerogels can be tailored for specific catalytic applications by controlling the crosslinking kinetics. The resulting materials offer a sustainable and efficient platform for catalytic processes, aligning with the goals of green and circular chemistry.