

Advanced GO-based hydrogels for controlled hyaluronic acid release in knee osteoarthritis treatment

Roya BINAYMOTLAGH^{*1}, Laura Chronopoulou¹, Alessandra Deangelis¹, Rita Gianfagna¹, Damiano Petrilli¹, Francesca Sciandra², Francesco Amato¹, Andrea Giacomo Marrani¹, Cleofe Palocci¹

¹ *Department of Chemistry, Sapienza University, Rome - Italy*

² *SCITEC-Consiglio Nazionale delle Ricerche, Rome - Italy*

Osteoarthritis (OA) is a prevalent chronic pain syndrome and a leading cause of disability worldwide, characterized by progressive deterioration of articular cartilage. This degradation leads to pain, swelling, inflammation, and eventual stiffness as the cartilage wears down, causing bone-on-bone friction. Current medical treatments primarily aim at pain relief; however, many interventions, especially invasive or surgical ones, carry risks of adverse outcomes. Consequently, intra-articular (IA) therapy, particularly hyaluronic acid (HA) injections, is widely adopted as a conservative treatment option. HA plays a crucial role in maintaining joint homeostasis by supporting proteoglycan synthesis and scaffolding, restoring optimal HA concentrations in synovial fluid, and providing chondroprotective and anti-inflammatory effects. In recent years, hydrogels composed of natural and synthetic materials have emerged as promising candidates for OA treatment. Our research focuses on the biosynthesis and characterization of novel hydrogel composites combining short peptide hydrogelators with graphene oxide (GO) nanosheets functionalized with HA (patent pending). These GO@HA@Hydrogel nanocomposites are designed to facilitate the controlled release of HA into the extracellular matrix, aiming to promote cartilage regeneration and mitigate inflammation. This project harnesses the oxygen-containing functional groups of GO nanosheets to enable covalent coupling or physical adsorption of HA molecules through various chemical approaches. The resulting GO-bioconjugates are incorporated within hydrogel matrices to achieve sustained and controlled HA release. We will systematically study how GO nanofillers influence the native hydrogel structure and its viscoelastic properties, which are critical for mimicking the mechanical environment of native cartilage tissue. Through this multidisciplinary approach combining advanced materials science and cellular biology, this work aims to develop innovative nanocomposite hydrogels capable of delivering HA in a controlled manner, enhancing cartilage repair and providing a potential therapeutic strategy for OA management.