ABSTRACT
Carbon nanotubes (CNTs) and Graphene sheets (GSs) are 1D and 2D structures, respectively, made of carbon atoms. They are electrically and thermally conductive and have unique mechanical properties. Carbon-based nanoparticles have potential applications in many fields, including organic electronics, reinforced and electrically conducting composites and even new types of biological sensors and devices. Promising processing routes involve suspensions of carbon nanoparticles. However, to fully exploit these suspensions, control of the microstructure evolution during flow is required. Specifically, a full understanding of the orientation dynamics of the nanoparticles during flow is necessary. In this work, we analyze the orientation dynamics of CNTs and GSs suspensions in the dilute regime by examining their rheo-optical response via small angle x-ray scattering (SAXS) and dichroism. The orientation of the systems is studied in simple shear flow and, for GSs, using large amplitude oscillatory shear (LAOS) as a prototype transient flow. In LAOS, the suspensions present an interesting double peaked response of the orientation angle at large strains during oscillation. To explain flow behavior of CNTs and GSs suspensions in simple steady shear and in LAOS, the particles are modelled as spheroids (in the limit of infinite and zero aspect ratio for CNT and GS, respectively) and the suspension orientation dynamics are captured by a single particle Smoluchowski equation. The microstructural response of the model predicts well the dynamics of these nanoparticles. The predictions of the model are then extended to nematic state where we demonstrate that LAOS is a more efficient technique than simple shear flow to probe fully the rheology and microstructures of these systems.