High pressure Raman study of Kevlar-29 aramide fibres

F. Sebros[1], J. Arvanitidis[1], D. Christofilos[2], S. Ves[1], J. Parthenios[3], G. Anagnostopoulos[3], C. Galiotis[3,4], and K. Papagelis[5]

[1]Physics Department, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[2]Chemical Engineering Dept., Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[3]Institute of Chemical Engineering, FORTH/ICE-HT, 26500 Patras, Greece
[4]Chemical Engineering Department, University of Patras, 26504 Patras, Greece
[5]Department of Materials Science, University of Patras, 26504 Patras, Greece

Abstract: Kevlar-29 aramide fibres (poly-p-phenylene terephthalamide, PPTA) is a light weight, high strength material extensively used in ballistic applications, ropes and cables, protective apparel, helmets, vehicular armoring and plates, rubber reinforcement in tires etc. Kevlar fibres consist of polymeric chains where amide groups are attached directly between two aromatic rings. These long chains are highly oriented with many interchain hydrogen bonds and aromatic stacking interactions. In this work, Raman spectroscopy (λ_{exc}= 515 nm) has been used to study the pressure response of Kevlar-29. Hydrostatic pressure up to 5.5 GPa was applied by means of a diamond anvil cell using glycerol as pressure transmitting medium and the ruby fluorescence technique for pressure calibration.

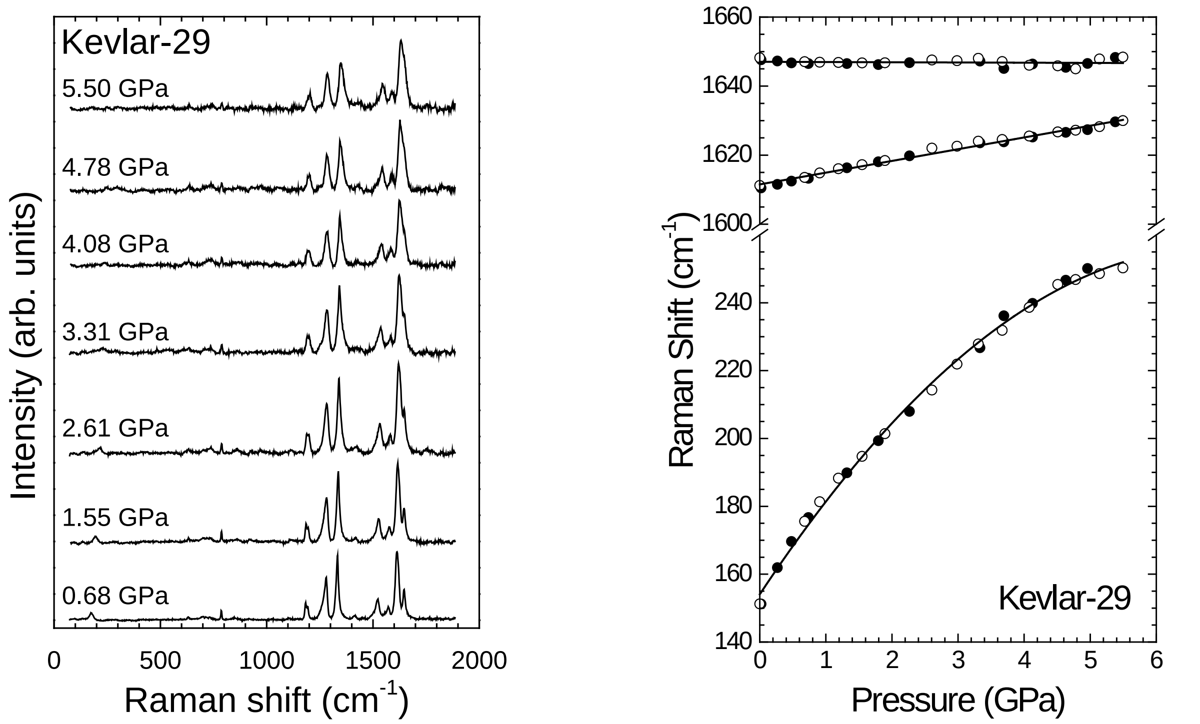

Figure 1. *Pressure evolution of Kevlar-29 Raman spectra and pressure dependence of selected peak frequencies.*

With increasing pressure, the majority of the observed Raman peaks shift to higher frequencies with slopes 1.2-6.2 $cm^{-1}GPa^{-1}$, without significant changes in their lineshapes and relative intensities (Figure 1). Interestingly, the Raman peak at 787 cm^{-1}, attributed mainly to ring puckering, exhibits a pressure slope of only 0.5 $cm^{-1}GPa^{-1}$, suggesting that despite the volume reduction upon pressure application, the ring environment associated with this out-of-plane vibration is not significantly altered. Moreover, the peak at 1647 cm^{-1}, attributed mainly to the C=O stretching vibration (Amide I band), displays a nearly zero pressure slope (-0.1 $cm^{-1}GPa^{-1}$), indicating that the volume reduction is somehow absorbed by the much weaker hydrogen bonds. Finally, the lowest frequency Raman peak (154 cm^{-1}) exhibits a relatively strong intensity attenuation and a sublinear pressure response with initial slope as high as 29.4 $cm^{-1}GPa^{-1}$, implying that it could be assigned to an external mode. All the observed changes are reversible upon pressure decrease.