be measured and in-depth sequence information (fractions of GG, MM, GGM, MGM, etc.) can be gained [38].

The chemical shifts in ^{13}CNMR spectra assigned to distinctive peaks of mannuronate (MM) and guluronate (GG) in each block are as follows (in ppm): $\delta_{MM-1} = 98.47$, $\delta_{MM-2} = 68.78$, $\delta_{MM-3} = 70.06$, $\delta_{MM-4} = 76.05$, $\delta_{MM-5} = 74.40$, $\delta_{MM-6} = 173.99$, $\delta_{GG-1} = 99.71$, $\delta_{GG-2} = 63.55$, $\delta_{GG-3} = 67.71$, $\delta_{GG-4} = 78.99$, $\delta_{GG-5} = 68.58$, $\delta_{GG-6} = 174.21$ [39].

In proton NMR spectra, the characteristic peak of the guluronic acid anomeric proton (G-1) occurs at 5.06 ppm (peak I); guluronic acid H-5 (G-5) at 4.4 ppm (peak III); and mannuronic acid anomeric proton (M-1) and the C-5 of alternating blocks (GM-5) overlapped at 4.7 ppm (peak II) [40, 41]. The individual guluronic acid (F_G) and the doublet (F_{GG}) fractions can be calculated from the area under the peak (I to III) using the following equation.

$$F_G = A_I/(A_{II} + A_{III});\ F_{GG} = A_{III}/(A_{II} + A_{III}) \quad (2.1)$$

The fraction M can be determined by Equation (2.2),

$$F_M = 1 - F_G \text{ and the M/G ratio is given by } M/G = (1 - F_G)/F_G \quad (2.2)$$

The disadvantage of solution-state NMR of alginates is that it needs partial acid hydrolysis, which results in tedious sample preparation and the chance for some insoluble material to be lost to quantitation [40].

2.3.3 Rheology and Mechanical Characterization of Alginate Gels and Solutions

Since alginates have a gelling behavior, the physics of deformation and flow of matter is of interest. The rheological behavior of alginates in aqueous dispersions was determined at various alginate concentrations and temperatures in the ranges 0.12.5–1.5% w/v and 278.16–308.16 K, respectively. The shear diagrams displayed typical pseudo plastic behavior. The effect of temperature on the consistency index (K) at constant alginate concentration was explained by a better-fitting power-law model than the Arrhenius relationship. Estimation of the thickening capability of any alginate solely based upon its average molecular weight was possible. The apparent viscosity of pseudo plastic alginate solutions depends on concentration, shear rate, and temperature. A 0.5% medium viscosity Na-alginate solution behaved in a Newtonian manner at low shear rates 1–100 sec^{-1}, but changed to pseudo plastic behavior only at high shear rates greater than 1000 sec^{-1} [42].