cross-linker. The elasticity of gel depends on the molecular weight that can be changed according to the molecular weight of the PEG molecules. PEG hydrogels can be formed by either adipic acid dihydrazide (AAD) as a bifunctional cross-linking molecule or poly(acrylamide-co-hydrazide) as a multifunctional cross-linking molecule. In covalent cross-linking, multifunctional cross-linking provides a wide range, control over degradation rates, and mechanical stiffness for stronger hydrogel [46]. PAG hydrogels were formed with either poly(acrylamide-co-hydrazide) as a multifunctional cross-linking molecule or adipic acid dihydrazide (AAD) as a bifunctional cross-linking molecule. This multicross-linking strategy led to the formation of stronger hydrogels.

10.3.6 Large Bead Preparation

For the preparation of a larger diameter bead, there is a need for a larger size needle to be used in the formation of beads and high viscosity solution. Viscosity also affects the shape of beads. Beads of size greater than 1.0 mm were prepared by either using a needle or a pipette [27, 47–51]. Sodium alginate is a good solution for the formation of larger beads, as with the increase in the viscosity of solution, formation of spherical beads occurs. There is a drawback of sodium alginates due to the presence of soluble proteins in sodium alginate solution that disturb the divalent cross-linking [52]. The formed beads are totally cured by cross-linking by divalent ions before rinsing with distilled water. The finally formed external alginate is coated with poly-L-lysine. Fourier transform infrared spectroscopy has shown that high β-D-mannuronic acid content in alginate beads is strongly coated with poly-L-lysine [53] and stored in 0.9% NaCl solution.

10.3.7 Microbead Preparation

Atomization, emulsification, and coacervation are the three different methods for preparation of small size beads less than 0.2 mm in diameter. The more often used technique is atomization or spraying method [54–59]. Formation of microbead procedure is as follows. Solutions containing the alginate and protein, as described above in the preparation of large beads, are well mixed and loaded into a syringe mounted on a syringe pump. The mixture of alginate and protein solution that was already mentioned in the large beads method is forwarded through an atomization device with a smaller diameter orifice at the tip. The size of beads depends on the used pressure of nitrogen gas, rate of flow through syringe, and distance between orifice and surface. Microbeads are finally coated with