and gas. The solid part provides mechanical property; the liquid and the gaseous parts of the composite weaken the properties by reducing the intermolecular interaction of the polymer chains, which are the only source for the mechanical strength. Higher molecular weight polymers provide better hydrogels swelling and higher mechanical properties.

Considering the hydration process, when the dry hydrogel comes in contact with water, the latter attacks the polymer surface of hydrogel, hydrates the polar groups starting to make up the bound water layer (Barbucci and Pasqui 2013). As soon as the polar groups are hydrated, the network starts to swell, i.e., starts expanding, allowing other solvent molecules to penetrate within the hydrogel network. The polymer chains change their conformation leading to increase the water mobility, while the hydrophobic groups will begin to aggregate among them finding a hostile environment, which is the aqueous one. After this first process where not all the polar groups are hydrated, the network will absorb a further amount of water, due to osmotic pressure that pushes the polymer chains to an infinite dilution. This water goes to hydrate other naked polar groups, forming other bound water layers, and to fill the space between the already hydrated with bound water polymeric chains. This process creates the interstitial water layer. The swelling is opposed by the covalent and physical crosslinks, which give rise to the elastic force. The interstitial water puts both the water and the hydrogel in contact with the external environment because it links the free water, which keeps the characteristics of the water in the bulk. At last, at the equilibrium where the elasticity and osmotic forces are balanced, there is no additional swelling.

Increasing the number of ionic groups in the skeleton of the polymer increases the swelling capacities of hydrogel. This is due to the simultaneous increase of the number of counter-ions inside the gel, which produces an additional osmotic pressure that swells the gel (Flory 1953). Furthermore the ionic polymers lead to a hydrogel with a swelling dependence on ionic strength, inferior mechanical properties, and brittleness in dry and swollen states. The swelling can be suppressed with increasing salt concentration in the external solution, which decreases the concentration difference of the counterions between the inside and outside the gel phase. Figure 17 illustrates the typical swelling behaviour of ionic PAAm hydrogels of various charge densities in water and in aqueous NaCl solutions (Durmaz and Okay 2000). The ionic comonomer used in the hydrogel preparation is 2-acrylamido-2-methylpropane sulfonic acid (AMPS). AMPS sodium salts dissociate completely over the entire pH range so that AMPS Na containing hydrogels exhibit pH-independent swelling. Increase of the AMPS Na content from 0 to 80 mol % results in a 27-fold increase in the hydrogel volume in water. In 1.0 M NaCl solution, the swelling ratio is almost independent on the ionic group content due to screening of charge interactions within the hydrogel.

Several investigations concern the behaviour of no-charged hydrogels such as polyvinyl alcohol (PVA), Guar Gum (GG), polyethylene glycol (PEG), etc. (Gun'ko et al. 2005). It was revealed the clear hydrophilic character of these polymers manifests in the formation of polymer-water hydrogen bonds and in the preferential solvation by water (Varghese et al. 2000). The analysis of hydrogen bond lifetimes has shown that the solvent dynamics near the polymer is slower than in the bulk. This is correlated to the number of hydrogen bonds, which typically increases in the vicinity of the no-charged