Chapter 5

Working Principle of Synthesized Polymers Acting as Dust Suppressant

5.1 Introduction

This chapter deals with the science behind the affinity of the synthesized polymers to the water. Here we understand how hydrogen bond is established between water molecules and polymer molecules to bind them together. Basic principle of any product to be used as a dust suppressant is that it should have the capability to bind water molecules within the parent molecules. Also evaporation rate of such bonded water molecules ~~is~~ should be low. Based on the above logic, the science behind the working principle of a polymers acting as a dust suppressant can be explained as discussed below.

5.2 Chemistry behind PAM to work as a dust suppressant

Polyacrylamide (PAM) has amide function group, which has capability to form hydrogen bond with water molecules as depicted in Figure 5.1. It consists of an -$CONH_2$ group and tendency to make hydrogen bond with four water molecules. Solubilization process of PAM in water is due to the insertion of water molecules in the interstitial space of PAM chain [102]**.** When water molecules come in contact with PAM molecules, initially swelling process of PAM starts. Thereafter, unfolding of PAM chain occurs inside the polymer. During unfolding, more water molecules ingress into the polymer matrix which directly increases the water holding capacity of PAM [103].

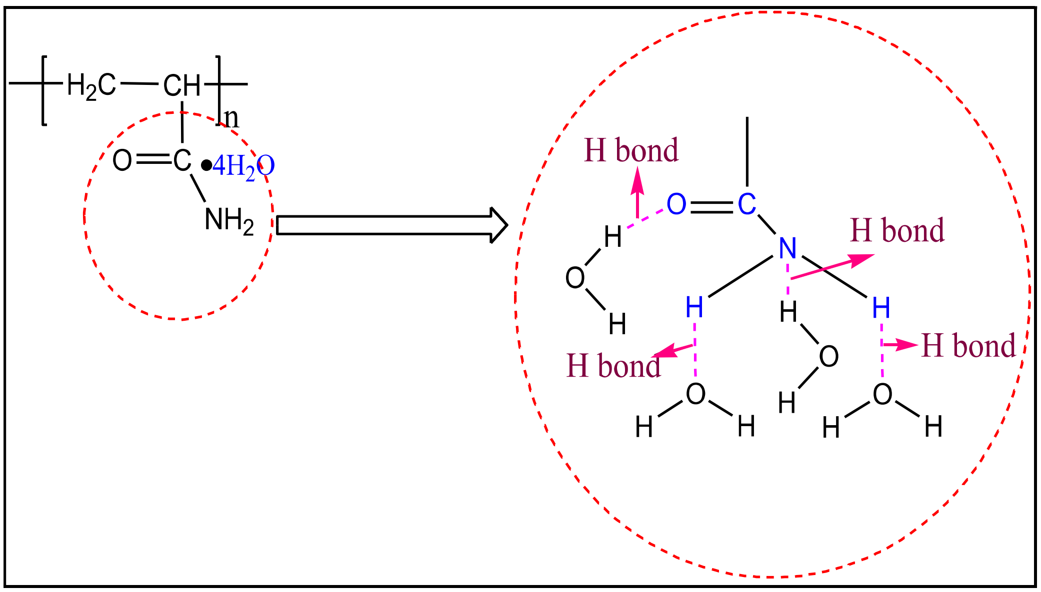

Figure 5.1 Formation of hydrogen bond between water molecules and amide group of PAM

5.3 Chemistry behind AP-g-PAM to work as a dust suppressant

In the grafted polymer AP-g-PAM, PAM side chains have been grafted over the amylopectin polymer backbone. A schematic presentation of AP-g-PAM along with formation of H-bond with water molecules has been shown in Figure 5.2. PAM has the capability to form hydrogen bonds with water molecules which is already explained in section 5.3.1. Amylopectin is viscous in nature and, thus, has capability to hold water molecules in its matrix. The main advantage of using AP is that it helps to make long branches of PAM, which ~~will~~ gives vast space for accumulation of water molecules. These actions combinedly increase the water holding capacity of the synthesized AP-g-PAM polymer.

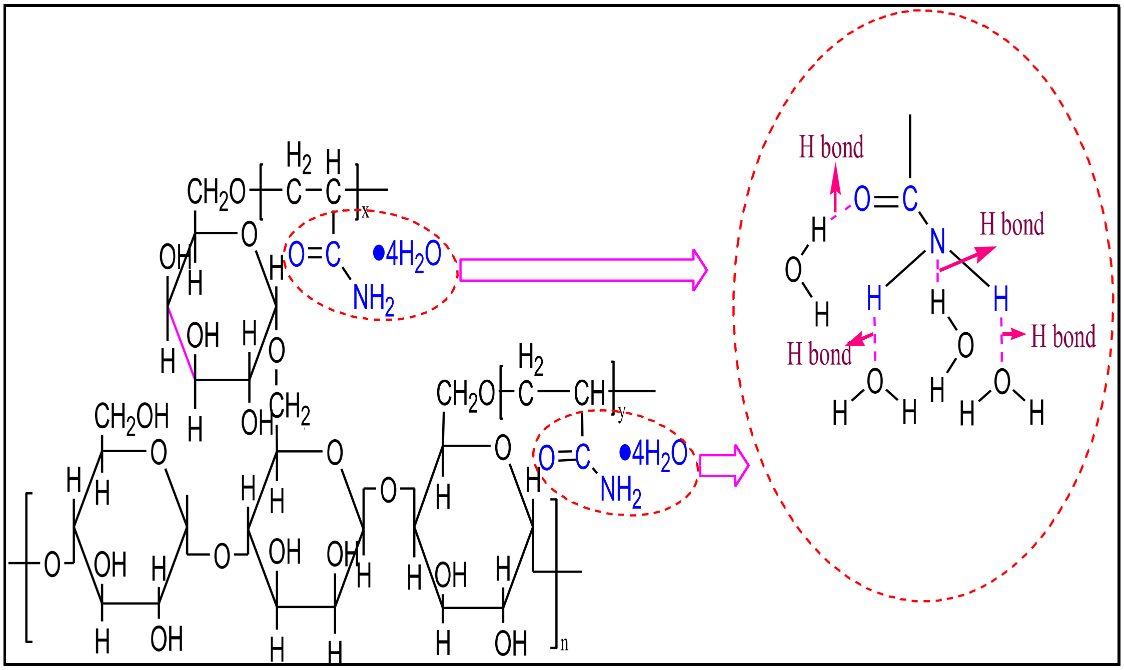

Figure 5.2 Formation of hydrogen bond between water molecules and amide group of AP-g-PAM

5.4 Chemistry behind GG-g-PAM to work as a dust suppressant

A schematic presentation for the structure of GG-g-PAM has been shown in Figure 5.3. Guargum has viscous as well as swelling properties to hold water molecules in its matrix. Due to more compactness of molecular structure of GG than AP, its moisture retention efficiency is high. By making multiple long branched chains of PAM in GG-g-PAM, it ~~will~~ would provide bigger network for holding water molecules.

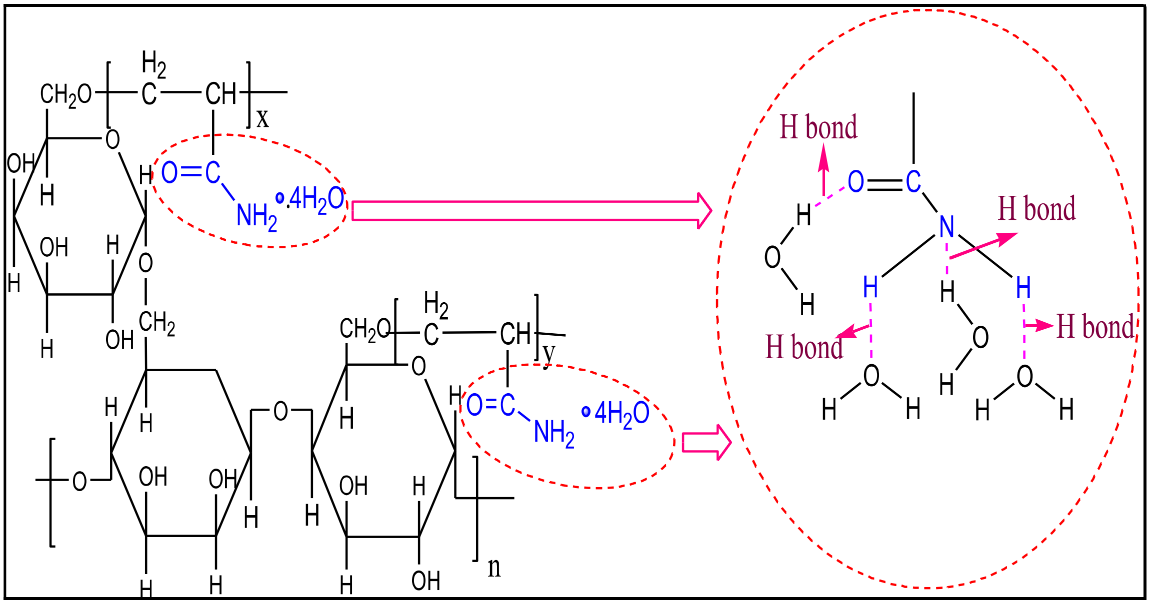

Figure 5.3 Formation of hydrogen bond between water molecules and amide group of GG-g-PAM

5.5 Chemistry behind PAMPS-co-PAM to work as a dust suppressant

A schematic presentation of PAMPS-co-PAM structure and formation of H-bond with water molecules has been shown in Figure 5.4. PAMPS-co-PAM has primary as well as secondary amide groups ~~and~~ along with one sulfonic group in ~~one~~ each unit of the co-polymer. Due to this, its accumulating capability of water molecules increases, which is higher than the other synthesized polymers. Amide group present in the PAM chain has affinity to make hydrogen bond with four molecules of water. On the other hand, amide group present in PAMPS chain, has capability for formation of three H bonds i.e. three molecules of water can attach with this functional group.

Sulfonic group has also tendency to hold four molecules of water by making H bond. It means, a single unit of PAMPS-co-PAM molecules can hold 11 molecules of water at a time.

This will support PAMPS-co-PAM to hold more water molecules for longer duration as compared to other polymers, namely, PAM, AP-g-PAM, GG-g-PAM and PAMPS-co-PAM.

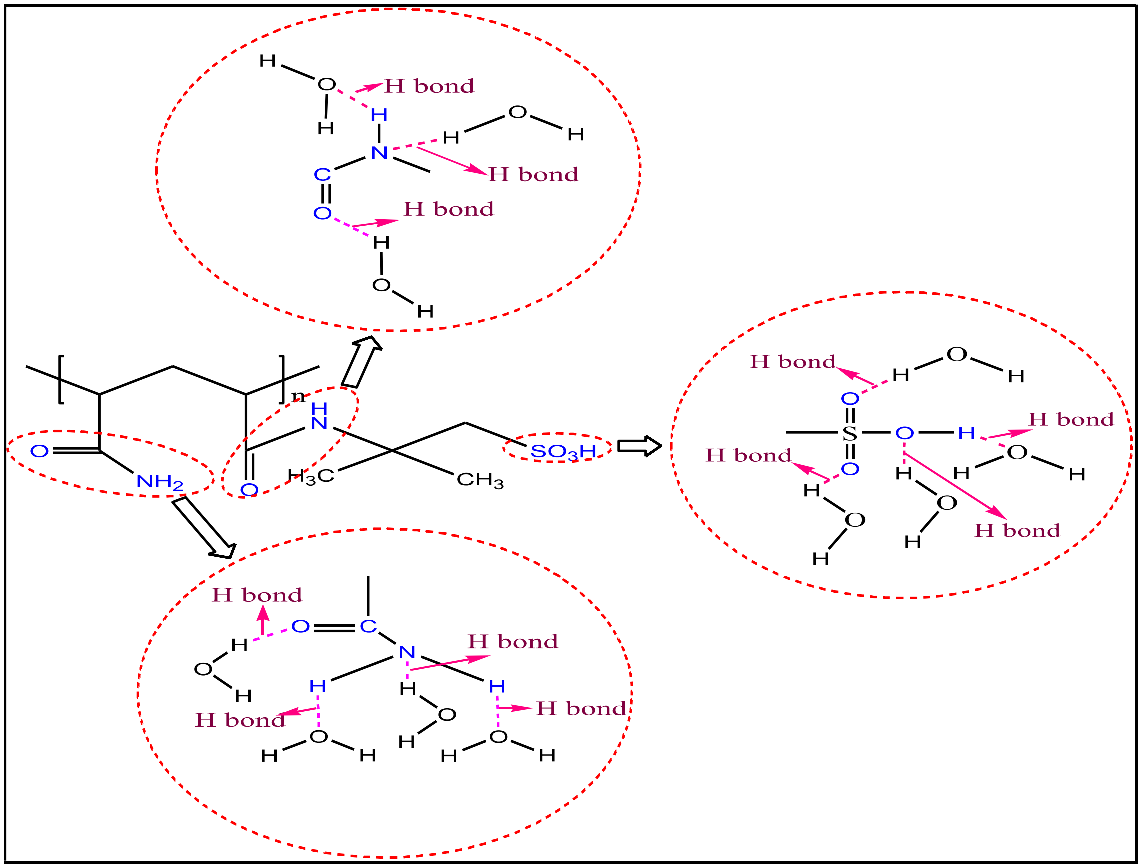

Figure 5.4 Formation of hydrogen bond between water molecules and amide group of PAMPS-co-PAM

5.6 Chemistry behind the hydrolyzed polymers acting as dust suppressant

Water absorbing capability of polymer depends on the solubility of the polymer in water. To increase the solubility, ionic character can be added to it.

By hydrolyzation of polyacrylamide in presence of NaOH solution, the carboxylate group ($CO\text{-}O^{-}Na^{+}$) is obtained in the end product which is ionic in nature. This ionic terminal of polymer is responsible for high solubility of hydrolyzed PAM (H-PAM) in water. This ionic terminal of H-PAM will hold the water molecules more strongly than the amide group in simple PAM molecules. Because of this, the solution of H-PAM becomes more viscous. As a result, more PAM matrixes are available to hold more number of water molecules into it compared to the simple PAM solution. Other hydrolyzed grafted polymers also work in the similar manner as H-PAM.

In case of copolymer PAMPS-co-PAM, water comes in contact with PAMPS-co-PAM, and a hydrogen bond formed between water molecules and PAMPS-co-PAM by dipole-dipole interaction. But as in case of hydrolization of polymer (H-PAMPS-co-PAM), an ionic dipole-dipole interaction takes place between water molecules and PAMPS-co-PAM molecules which stronger than dipole-dipole interaction. Therefore hydrolyzed polymer can hold the water molecules for more time period then at given temperature.

Secondly in case of hydrolization, polymer molecules show ionic characteristic. These negative and positive charges developed within the carboxylate group are repelled by other negative and positive charges of carboxylate group respectively. For this reason, molecules of polymer start expanding and straightening. As a result, larger space is available to accumulate more number of water molecules. Due to this, H-PAMPS-co-PAM gives better moisture retention efficiency as compared to normal PAMPS-co-PAM or other polymers.