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Influence of Strain on Dynamic Viscoelastic Properties of Swelled (H_2O) and Biomineralized ($CaCO_3$) PVP-CMC Hydrogels

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Abstract:
This paper reports the rheological behavior of swelled and mineralized hydrogel prepared using polyvinylpyrrolidone (PVP) and carboxymethylcellulose (CMC) hydrogel as base polymer. Herein, the bio-mineral calcium carbonate ($CaCO_3$) was incorporated into the hydrogel using simple liquid diffusion method. The morphology of the swelled and mineralized hydrogel was analyzed through scanning electron microscopy. Further, the normalized time of absorptivity was identified from the time dependent absorptivity behavior of calcite and water filled PVP-CMC hydrogel. The effect of the biomineral ($CaCO_3$) and water on the dynamic viscoelastic properties, after penetrating inside the hydrogel matrix has been evaluated. The frequency sweep at 1 and 10 % strain and also strain sweep measurement were performed to determine the frequency and strain dependent viscoelastic moduli *G'* and *G"* of both swelled and mineralized hydrogel. At higher strain the both moduli showed significant change over wide range of angular frequency region and the nature of mineralized polymer composites (MPC) turned from elastic to viscous. Based on the observed basic properties, MPC (calcite based polymer composites) can be recommended for the treatment of adyanamic bone disorder and water swelled hydrogel can be acclaimed as a scaffold for burned wound dressing.

Key words:
PVP-CMC hydrogel, swelled and mineralized hydrogel, viscoelastic properties

1 INTRODUCTION

Hydrogels being hydrophilic polymeric materials are intensively in demand as their remarkable properties like huge water absorption capacity retaining their structural integrity, flexibility, biodegradability, biocompatibility etc. have made it possible to implement as soft material in many biomedical fields like scaffolds for tissue engineering, therapeutic drug delivery, as wound dressings and other medical device fabrication [1–12]. Hydrogels can be prepared from diversed materials that include synthetic polymers along and natural based polymers. These days' biopolymers are much in demand as they provide three dimensional environment and morphology close to extracellular matrices of native tissues [13–15].

Polymeric based hydrogels can be distinguished as either physical or chemical systems. Chemical gels can be explained as 3D-molecular network in which adjacent polymer chains are cross-linked covalently [16]. On other hand, physical gels have polymer chains linked together by secondary molecular forces like hydrogen bonding, van der Waals force, and covalent bond [16]. The polymeric biomaterial prepared using the blended form of natural and synthetic material is given much attention by the material scientists. Polyvinyl pyrollidone (PVP) being synthetic polymer is widely used in the biomedical applications because of its biocompatibility and nontoxic in nature. As such PVP alone has not much swelling properties but when mixed with any natural polymers or polysaccharides its properties are improved [1]. Polysaccharides like alginic acid/ alginate, cellulose/carboxymethyl cellulose (CMC), chitin and chitosan, based hydrogels being abundant in nature, non-toxic and biodegradable so are in focus [1, 15, 17, 18].

Biomimetic materials preparation is of great inspiration to the material scientist who is involved in understanding the mechanisms and principles behind several mineralization phenomenon [19]. Moreover, biomineralization offers another way to enhance specific cell-

to be relating with the gradually fracture of the internal structure of water absorbed hydrogel under higher strain region, and as the result, viscous nature of the gel increase more quickly in comparison with that of mineralized gel shown in Figure 10a in which we do not observe clearly this behavior. In Figure 11b for 90 minutes water absorbed hydrogels, the trend of the curves is similar to 10 mins curves although there is the change of the absolute values of *G'*, *G"*, and critical strain.

4 CONCLUSION

The liquid diffusion technique was used to achieve the PVP-CMC-H_2O (water swollen hydrogel scaffold) and PVP-CMC-$CaCO_3$ (biomineralized polymer composites (MPC)). The morphological image confirms the existence of porous structure within the PVPCMC hydrogel matrix as well as uptake of water by dry PVP-CMC hydrogel and the deposition of $CaCO_3$ within the hydrogel matrix. Both PVP-CMC-H_2O and PVP-CMC-$CaCO_3$ are flexible in nature. Water swelled PVP-CMC biomaterial maintained its elastic and viscous behavior depending upon its water uptake. In the case of PVP-CMC-$CaCO_3$, the mineralized polymer composites, 90 min is the optimum duration for biomineralization process. The frequency sweep at 1 and 10 % strain and also strain sweep measurement were performed to determine the frequency and strain dependent viscoelastic moduli (*G'* and *G"*) of both swelled and mineralized hydrogel. At low strain, elastic property expressed by *G'* was more predominant than the viscous properties expressed by *G"*, however both moduli changed significantly at higher strain over wide range of angular frequency region. Further, the nature of mineralized polymer composites (MPC) turned from elastic to viscous. The calcite filled biomaterial investigated here can be utilized in biomedical applications like adyanamic bone disorder and water swelled hydrogel can be acclaimed as a scaffold for burned wound dressing.

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