POLYETHER ETHER KETONE REINFORCED CHITOSAN-POLYETHYLENE GLYCOL COMPOSITES FOR BIOMEDICAL APPLICATION

Payal Mukherjee[1], Tejinder Kaur[2], Namasivaya Naveen S[2] and A. Thirugnanam[2*]

[1]School of Biotechnology, KIIT University, Bhubaneswar, Odisha 751024.

[2]Department of Biotechnology and Medical Engineering,
National Institute of Technology Rourkela, Odisha 769008.

ABSTRACT:

Chitosan (CS), a naturally occurring polysaccharide, is widely being used for medical and pharmaceutical applications owing to its biocompatibility and biodegradability. However, its brittle nature and weak mechanical properties often limit its application in the biomedical field. Therefore, the aim of the present study is to reduce the brittle nature of the CS films by addition of polyethylene glycol (PEG) and to further improve their mechanical properties by reinforcing with the polyether ether ketone (PEEK). Briefly, CS (2% w/v) was dissolved in 2% acetic acid solution and stirred overnight at 37˚C. PEG in the concentration of 1% w/v was added to the CS solution and stirred again for 6 h. In the CS-PEG composite, PEEK was added at concentrations of 0.1% and 0.5% w/w (w.r.t. CS) to develop CS-PEG-PEEK composites. Thus developed three different composites were named as CP (CS-PEG), CP 0.1 (CS-PEG-0.1% PEEK) and CP 0.5 (CS-PEG-0.5% PEEK). The composites were characterized by performing scanning electron microscopy (SEM), X-ray diffraction and Fourier transform infrared study. The contact angle measurement, swelling studies, degradation studies, hemocompatibility and protein adsorption studies were also performed. The mechanical properties of the composites were evaluated by performing tensile studies. The SEM micrographs showed well dispersion of PEG and PEEK in the CS matrix. The CP showed lowest contact angle values, whereas, the addition of PEEK increased the contact angle values of the composites. The PEEK containing samples (CP 0.1 and CP 0.5) showed less swelling percentage and degradation rate than the control (CP). All the samples exhibited <5% hemolysis values confirming their hemocompatible nature. The adsorption of protein on all the composites indicated their suitability for biomedical applications. Further, the reinforcement of PEEK in CS-PEG matrix improved the mechanical properties of the composites many folds. The above studies confirm the potential of CS-PEG-PEEK composites for biomedical implant applications.

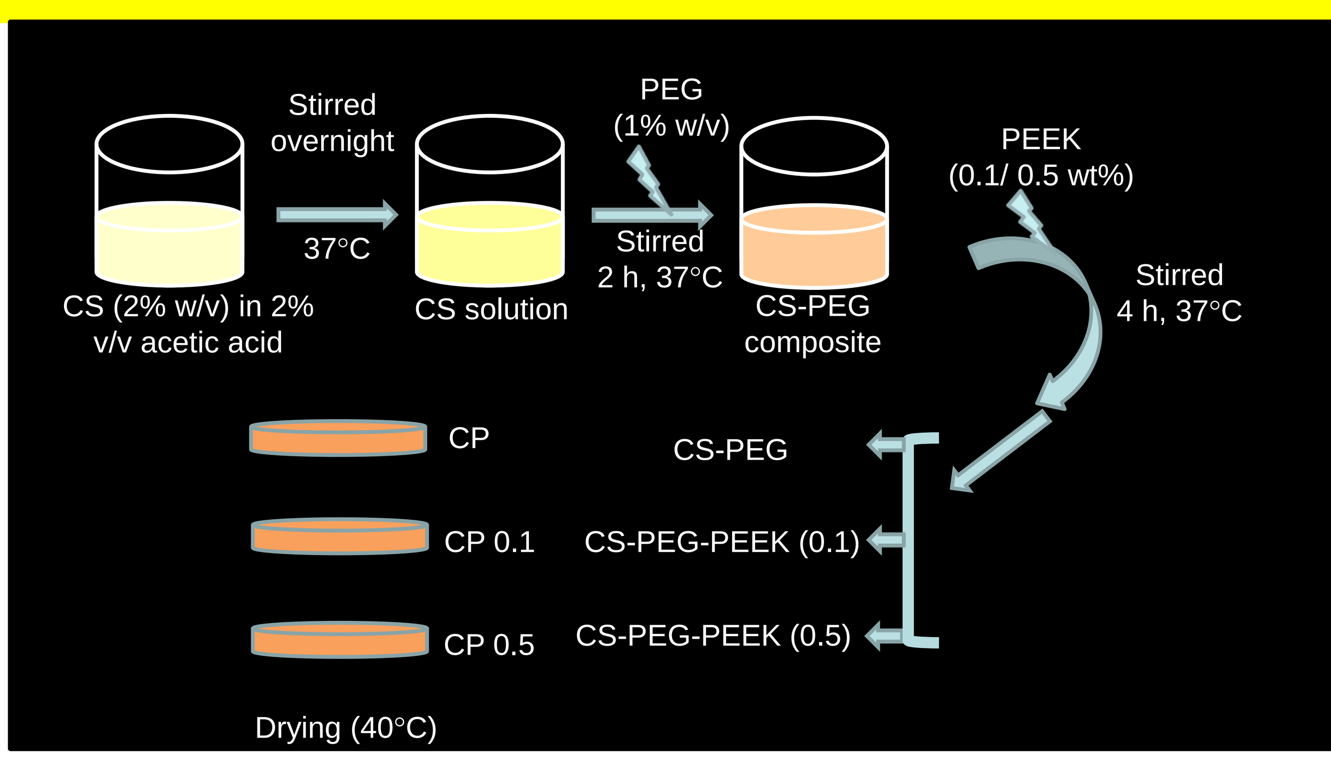
***Keywords*: chitosan, polyethylene glycol, polyether ether ketone, composite, degradation, biomedical applications**

INTRODUCTION

Chitosan (CS), a naturally occurring polysaccharide, is widely being used for medical and pharmaceutical applications owing to its biocompatibility and biodegradability. However, its brittle nature and weak mechanical properties often limit its application in the biomedical field. Therefore, the aim of the present study is to reduce the brittle nature of the CS films by addition of polyethylene glycol (PEG) and to further improve their mechanical properties by reinforcing with the polyether ether ketone (PEEK).

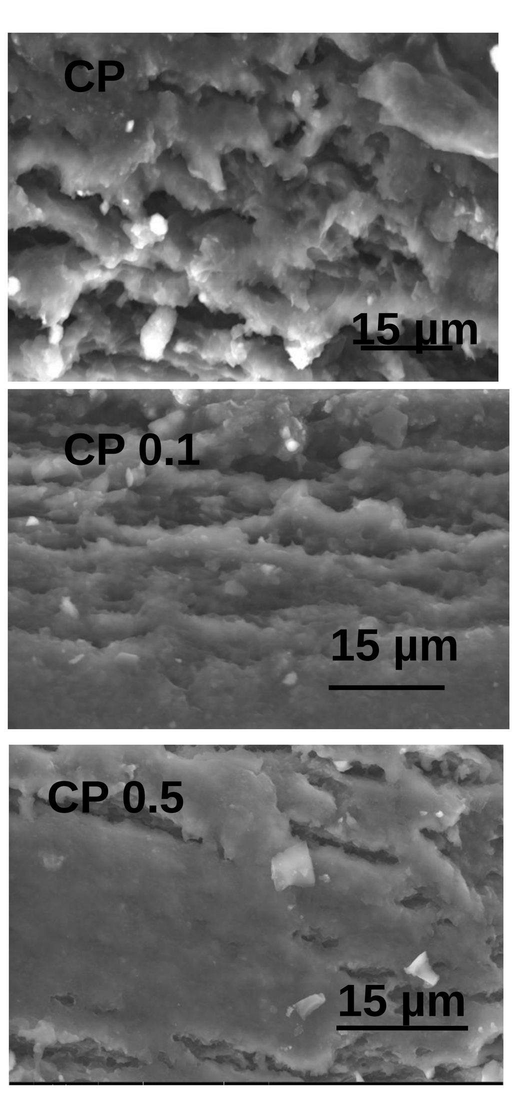
MATERIALS AND METHODS

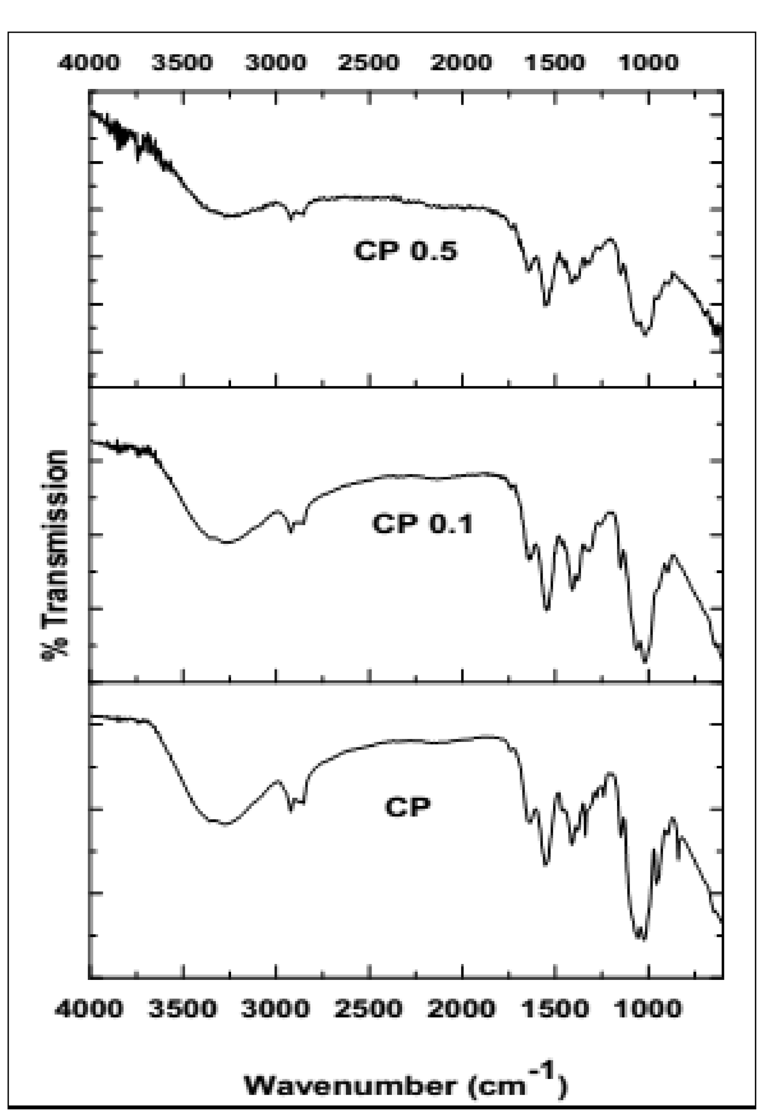
PREPARATION OF FILMS



CHARACTERIZATION

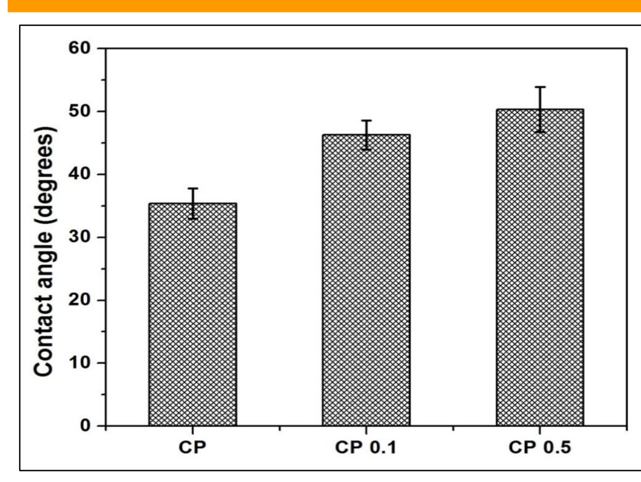
SCANNING ELECTRON MICROSCOPY AND FTIR





- There was not any agglomeration or aggregation of components observed.
- All the samples showed a broad peak around 3500 cm-1 and 2920 cm-1 indicating the presence of –OH groups and –CH groups.
- Other peaks were obtained at 1556, 1416 and 1008 indicating the presence of –COO and –CN functional groups.

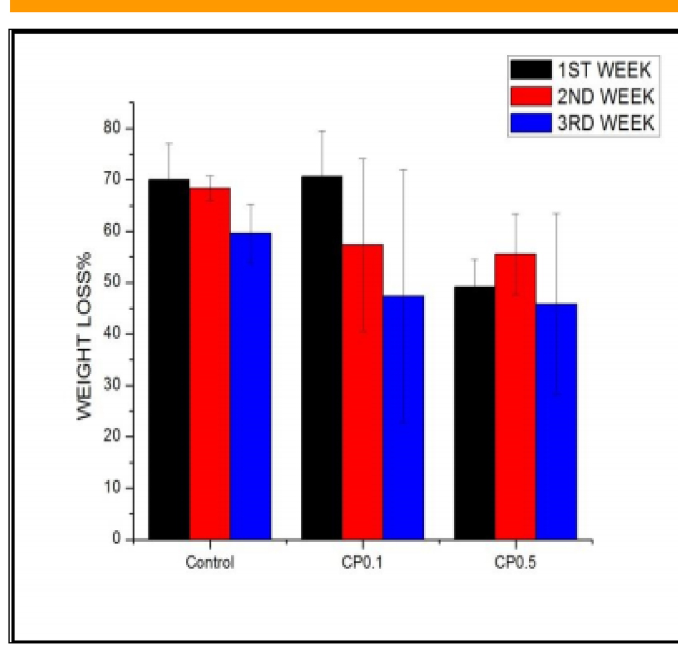
CONTACT ANGLE MEASUREMENTS



❖The addition of PEEK has increased the contact angle values for CP 0.1 and CP 0.5.

❖This shows that the PEEK containing samples are more hydrophobic than CP sample.

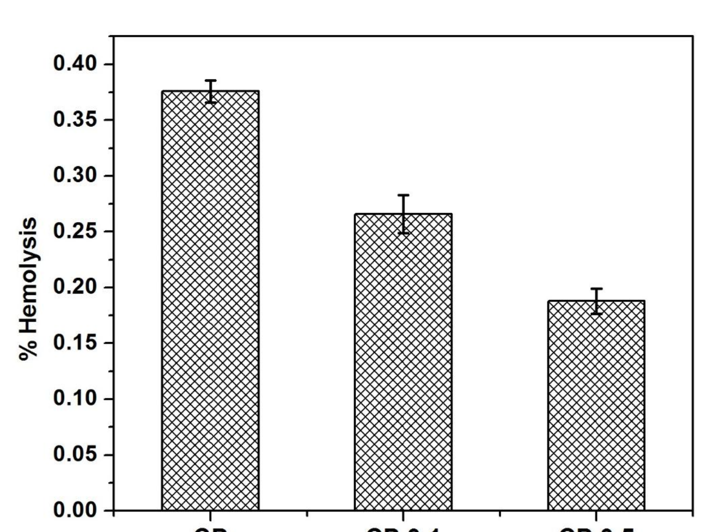
DEGRADATION STUDIES



❖CP sample showed highest degradation rate followed by CP 0.1 and CP 0.5.

❖A decrease in water absorption with the addition of PEEK leads to reduction in the degradation of both CP 0.1 and CP 0.5

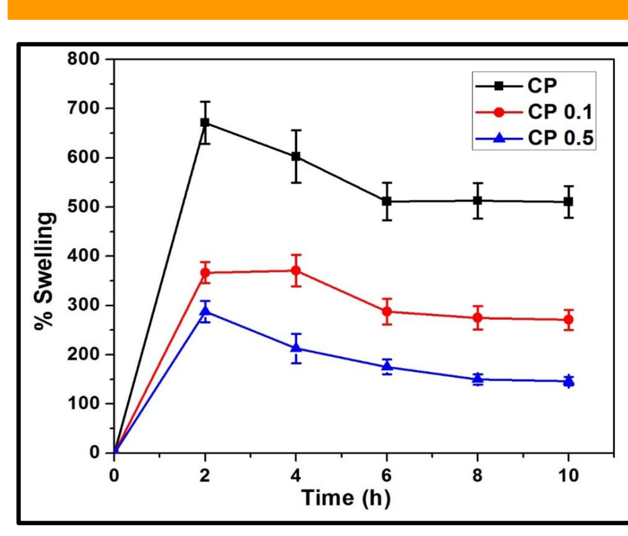
HEMOLYSIS STUDY



❖The hemolysis values for all the samples were less than 5%.

❖According to the ISO 10993-4 standard, biomaterials having up to 5% hemolysis are permissible

SWELLING STUDIES



❖CP sample showed highest swelling percentage owing to the hydrophilic nature of both CS and PEG.

❖With the addition of PEEK in CS-PEG matrix the swelling percentage was found to decrease due to the hydrophobic nature of PEEK powder.

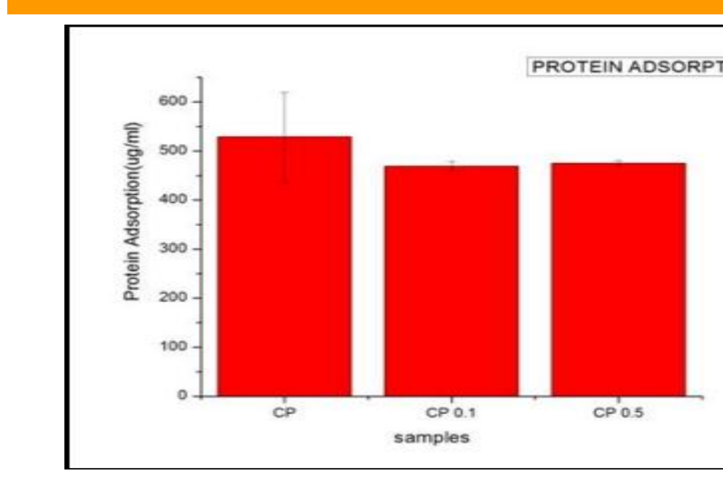
❖After 6 h of immersion, all the samples reached equilibrium state.

TENSILE PROPERTIES

Samples	Young's Modulus (MPa)	Tensile Strength (MPa)	Energy at Break (Standard) (J
CP	431.01405	11.73	0.07406
CP0.1	745.65257	14.74	0.00331
CP0.5	780.7046	18.96	0.01215

- Addition of PEEK to the samples increased the values for tensile strength and Young's modulus due to homogeneous distribution of all components.
- The toughness of samples CP and CP0.5 was comparatively more than CP0.1

PROTEIN ADSORPTION



❖The CP sample showed lowest protein adsorption.

❖The addition of hydrophobic materials improved the protein adsorption on CP 0.1 and CP 0.5.

❖The augmented protein adsorption make the samples suitable for tissue engineering applications.

CONCLUSION

- Chitosan-PEG-PEEK composites so developed showed porous structures and all the individual components were found to be evenly distributed in the Chitosan matrix without any agglomerate formation.
- The addition of PEEK made the samples more hydrophobic leading to reduction in swelling and degradation properties.
- All the samples showed hemocompatible nature and overall good mechanical properties.
- An increase in protein adsorption and contact angle measurements made the PEEK containing samples more suitable for tissue engineering applications

BIBLIOGRAPHY

❖Anitha, A., et al., Chitin and chitosan in selected biomedical applications. Progress in Polymer Science, 2014. 39(9): p. 1644-1667.

❖2Kokubo, T. and H. Takadama, How useful is SBF in predicting in vivo bone bioactivity? Biomaterials, 2006. 27(15): p. 2907-2915.

❖3Kolhe, P. and R.M. Kannan, Improvement in ductility of chitosan through blending and copolymerization with PEG: FTIR investigation of molecular interactions. Biomacromolecules, 2003. 4(1): p. 173-180.