DEVELOPMENT OF BIODEGRADABLE PVA SPONGE INCORPORATED WITH ANTIMICROBIAL AGENT

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ABSTRACT

PolyVinyl Alcohol (PVA) is a synthetic polymer used in wide range of industrial, commercial, agriculture and medical application. It is environmental friendly, water soluble with excellent emulsifying properties. They are biodegradable and hence environmental friendly. The PVA sponges can be produced by using large closed reactors and hence are suitable for mass production. The preparation of the basic PVA solution is by adding the surfactant, catalyst, oxidizing agents, and formaldehyde. For PVA sponges many surfactants and softeners can be incorporated in order to improve its performance. The resultant PVA sponge is open-celled, highly absorbent porous material with good absorption property. The PVA sponge properties are characterized and optimized based on temperature it can withstand, height of the foam, agitation time, pH, pore structure, pore diameter, structure of the pore, chemical composition and antimicrobial activity. This paper refers to the development of PVA sponge incorporated with antimicrobial agents that is degradable which can be used for multiple applications including medical and agricultural applications.

KEYWORDS: polyvinyl alcohol, biodegradable, antimicrobial agents.

INTRODUCTION

Polyvinyl alcohol (PVA) sponge is a synthetic sponge essentially consisting of Polyvinyl Alcohol. It is an open celled, highly adsorbent porous material that wicks aqueous solutions quickly. It is compressible when dry, expandable when wet, has good elongation with excellent resistance to wear and tear.

PVA has low protein adsorption characteristics, better biocompatibility, high water solubility and chemical resistance. PVA, is biodegradable and hence is environmental friendly . PVA decomposes rapidly above 200℃ as it can undergo pyrolysis at high temperature.

The reaction of polymerization takes place between polyvinyl alcohol along with addition of catalyst, surfactants, blowing agent, softeners and curing agent. The formaldehyde employed comprises 37% aqueous solution and when compared to para formaldehyde, formaldehyde can be easily removed from the sponge by washing with water to obtain non-toxic levels of formaldehyde.

Various catalysts have been used in the process namely sulphuric acid, hydrochloric acid, phosphoric acid, nitric acid and formic acid. Surfactant are used to lower the surface tension, generally cationic and non-ionic surfactants are preferred. Other additives are added to increase the foaming height. Finally polyvinyl alcohol acetalised with an acid catalyst.

METHODOLOGY

SELECTION OF POLYVINYL ALCOHOL.

Primarily the texture of sponge varies on the basis of type of hydrolysed PVA with appropriate grade and molecular weight. Hence completely hydrolysed PVA with molecular weight of 25000 - 30000 are chosen for the process.

PREPARATION OF PVA EMULSION.

Completely hydrolysed PVA with appropriate grade and molecular weight has to be chosen. There amount of PVA preferred is about 20 to 30 percent. Polyvinyl alcohol is charged into deionised cold water and heated to get its emulsion . The basic solution is emulsified, if it forms clear solution.

ADDITION OF SURFACTANTS AND FORMALDEHYDE.

At this stage, Polyvinyl alcohol and wetting agent are combined and subjected to agitation to entrap air bubbles uniformly throughout the reaction system. The temperature of basic polyvinyl alcohol solution is been raised and cooled, the suitable surfactant is added and agitated. The relative amount of formaldehyde about 30 to 40 percent weight of PVA.

INCORPORATION OF CATALYST ALONG WITH OXIDIZING AGENT.

This is conveniently carried out by adding acid catalyst to the aqueous dispersion of Polyvinyl alcohol at room temperature while conducting agitation at room temperature. Along with catalyst, the suitable oxidizing agents like sodium hydroxide, hydrogen peroxide are used and agitated well at room temperature.

MOULDING AND CURING OF THE MIXTURE.

These mixture of solution are poured onto a preheated petriplates and the samples are cured in hot air oven for overnight at 50□c - 60□c. After this period of time, the samples in the mould precipitates the water and finally the samples are taken for further treatments.

PROCESSING OF PVA SPONGE.

The obtained raw sample is washed with water at least five to ten times to remove the unused reactants. The product sponges is treated with sodium hydroxide to neutralize the pH of sample. The pH of the sample is brought down from pH 3 to pH 6. Again the samples are washed several times to remove the content of sodium hydroxide.

Figure 1: Final PVA sponges.

ADDITION OF ANTIMICROBIAL AGENTS

Antimicrobial agent

An antimicrobial is an agent that kills microorganisms or stops their growth. Naturally available antimicrobial agent are incorporated in the sponge sample. Generally turmeric and neem extract are incorporated in the sponge during the process and again treated with these extracts after the curing process.

Fig 2: Antimicrobial agents - turmeric powder and neem powder.

Fig 3: Sponges that contains turmeric and neem powder.

Antimicrobial test

Sponges that are incorporated with antimicrobial agents are inoculated in nutrient agar. The sponges are incubated for 10 days and checked for growth of microorganism. The growth of microorganism was 1 cm apart from sponge. Hence this shows the antimicrobial property.

PREPARATION OF NUTRIENT AGAR

The components required for Nutrient agar

Peptic digest of animal tissue = 5 gms/ltr
Sodium chloride = 5gms/ltr
Beef extract = 1.5 gms/ltr
Yeast extract = 1.5 gms/ltr
Agar = 15 gms/ltr

All the above components are mixed as per the quantity required and autoclaved at 15 lbs for 15 minutes. This medium was poured onto petriplates and was allowed to cool, finally the microorganism was streaked. In the middle of petriplate the sample was placed and checked for antimicrobial activity by its physical changes.

Fig 4: Antimicrobial activity of the sample (a) the sample during inoculation and (b) sample after 10 days of incubation.

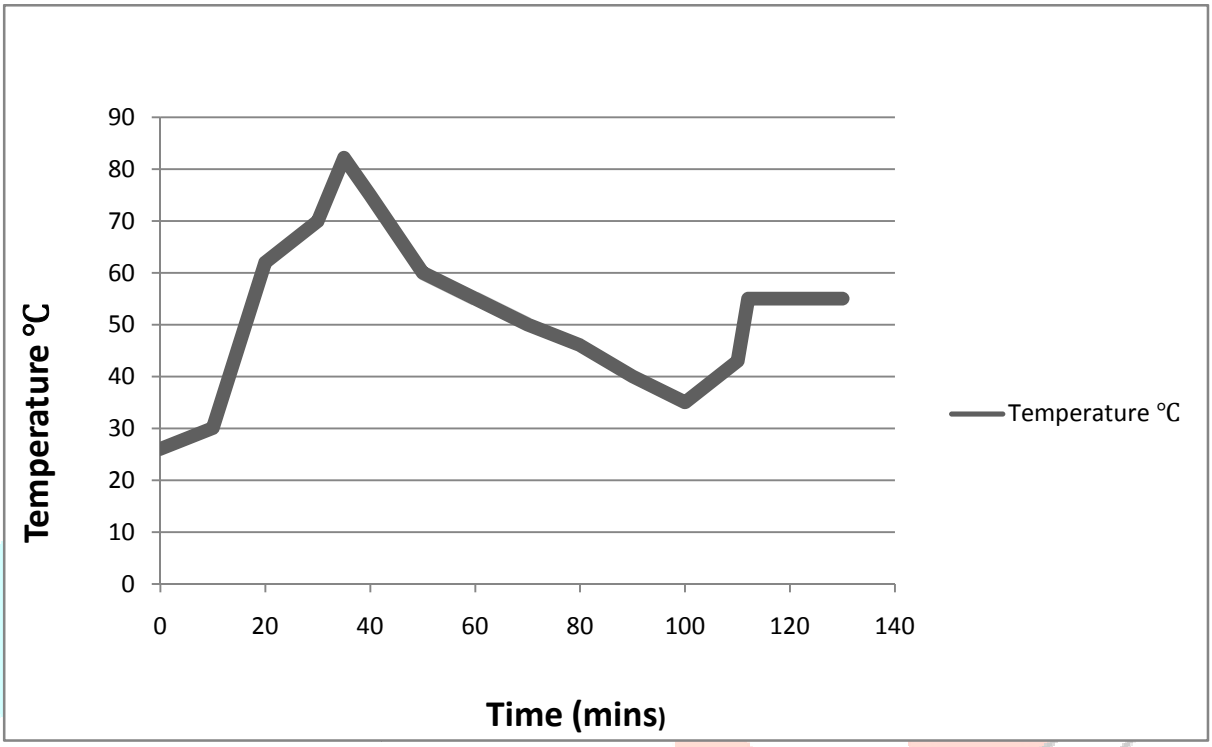
RESULTS

OBSERVATION

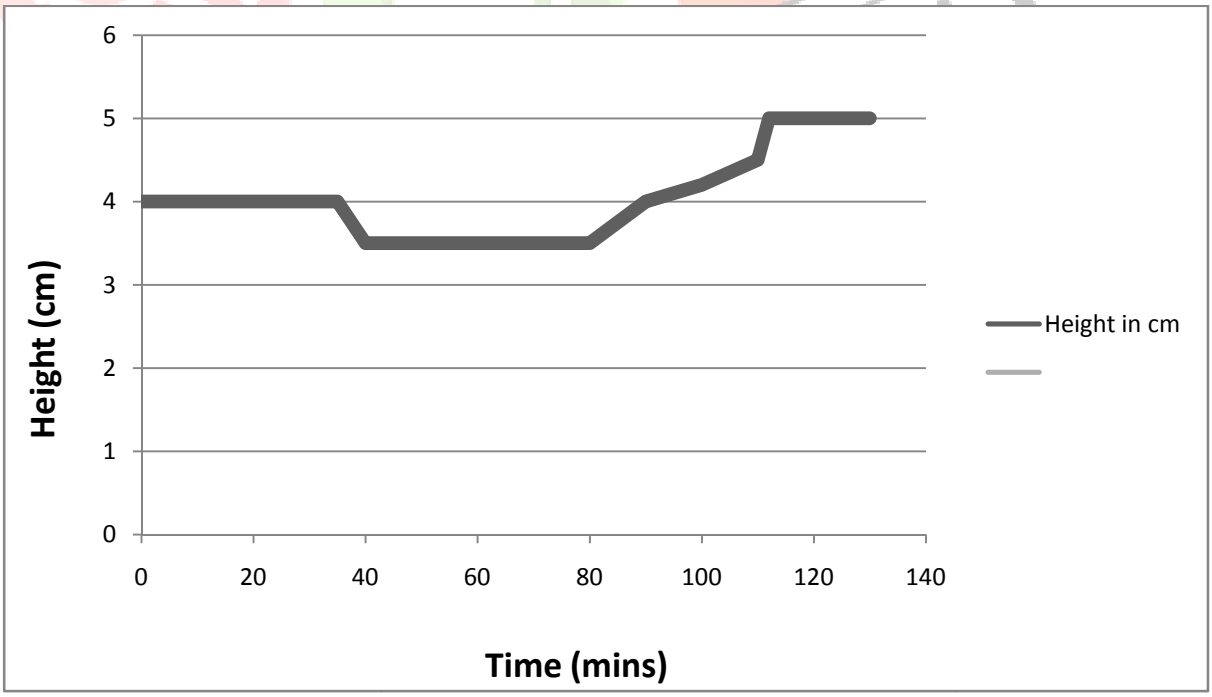
Sl No	Parameter	Temperature	Agitation Time
1	PVA + deionized cold water	Raised to 82.2□c	5 minutes
2	Surfactants	Cooled to 46.12-48.89□c	10 minutes
3	Acid catalyst	At 43.3-48.8□c	2 minutes
4	Formaldehyde (37%)	At 37.7-43.3□c	1 minutes

Table 1: Summary of components used to prepare PVA sponge.

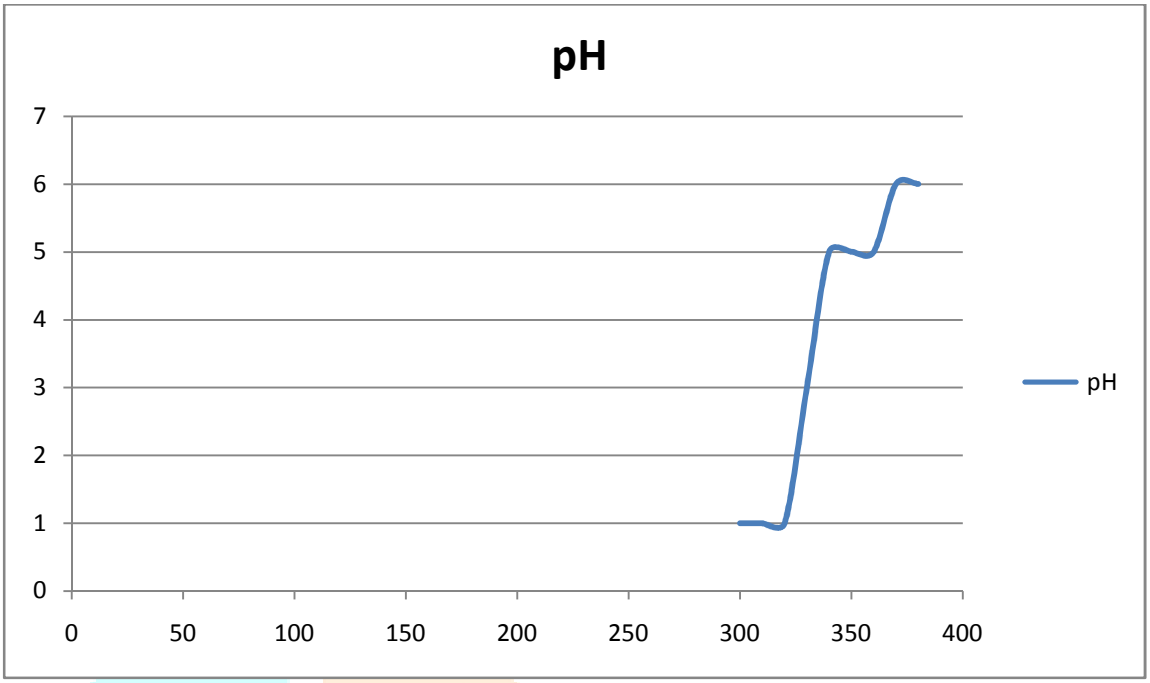
By addition of surfactants with varying temperature and agitation time ,the stabilized foam were formed throughout the entire sample for all the samples. After cooling , the foam solution is poured into the mould . Its slowly solidify by forming soft foam leaving a liquid phase on the bottom as shown in Figure 1.



Graph 1: Temperature profile with respective to process time.



Graph 2: Height profile with respective to process time before curing the product.



Graph 3: pH profile with respective to process time after curing the product.

DISCUSSION

The polymeric sponge greatly vary in texture and softness. This texture of sponges depends on the application of sponges. In this experimental the concentration of PVA solutions are varied with respective to formaldehyde, catalyst and other additives. The PVA solution of 10-15% concentration was used and the pore size decreases with increase in PVA concentration. As pore size is small, the absorption rate is higher. One main criteria that changed the texture of sponge was the curing time of the sponges at particular temperature. The overnight curing time gave the best results in softness and rate of absorption. The rate of absorption is four times more than the original weight of the sample.

CONCLUSION

Exposure of PVA mixture at particular temperature for over period of time makes the sponge more soft and absorbent. Among the varies composition the best resulted was PVA along with small amount of cellulose. The optimum temperature found good result at was 50□c - 60□c. The increase in curing time of the product makes the texture better. The sponge treated with antimicrobial agent such as turmeric and neem powders shows the better antimicrobial property. The Degradation of this sponge naturally takes upto 3-4 months under the influence of environmental conditions.

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