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# A DSC study of some biomaterials relevant to pharmaceutical industry

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**Abstract** The present investigation concerns with thermal analysis of biomaterials such as Chitosan, Xanthan gum, Guar gum Pectin, Karaya gum, Sodium alginate, and Psyllium husk mucilage. The DSC curve of the natural polymers showed its specific endothermic peaks and $\Delta H_f$ values, and these will be helpful in determining the fitness of the polymers with active drug. The drug and natural polymer compatibility study is now one of the recognized methods for preformulation step in pharmaceutical drug development. All the natural polymers showed endothermic peak below 150 °C, and this make them suitable with a wide class of therapeutic drugs.

**Keywords** Chitosan · Natural gums · Psyllium · Alginate · DSC

## Introduction

Biomaterial plays a vital function in pharmaceutical formulation development. They are used to play various roles because they possess properties such as biocompatibility, biodegradability, non-toxicity, and absorption enhancement. Recently, various studies were undertaken where researchers used differential scanning calorimetry (DSC) as analytical technique for compatibility study [1, 2]. Chitosan is a derivative of chitin, the second most abundant biomaterial in nature, which is a supporting material of crustaceans, insects, and fungal mycelia. Chitin is composed of 2-acetamido-2-deoxy-$\beta$-D-glucose units linked by a $\beta$-(1 → 4) linkage. Chitin was well explored in native and modified forms in drug development as a matrix former as well as mucoadhesive polymer [3–5].

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Psyllium seed husks are obtained from the seeds from the Plantago species. The D-galacturonic acid and L-arabinose are the major constituents of the mucilage. Psyllium husks were evaluated for drug delivery applications with various active agents. [6–8].

Pectin is a complex mixture of polysaccharides that makes up about one-third of the cell wall dry substance of higher plants. The highest concentrations of Pectin are found in the middle lamella of cell wall, and Pectin is thought to consist mainly of D-galacturonic acid units joined in chains by means of $\alpha$-(1 → 4) glycosidic linkage. The Pectin has been evaluated as controlled release and colon targeted polymer with various active pharmaceutical ingredients [9, 10].

Guar gum is obtained from the endosperm of the seed of the guar plant, *Cyamopsis tetragonoloba* (L.) Taub. (syn. *Cyamopsis psoralioides*). Guar gum is mainly consisting of the high molecular weight polysaccharides composed of galactomannans which are consisting of a linear chain of (1 → 4)-linked $\beta$-D-mannopyranosyl units with (1 → 6)-linked $\alpha$-D-galactopyranosyl residues as side chains. The mannose:galactose ratio is approximately 2:1 in guar gum [11].

Xanthan gum is a heteropolysaccharide, derived from the bacterial coat of *Xanthomonas campestris*. The primary structure of xanthan consists of repeating pentasaccharide units consisting of two D-glucopyranosyl units, two D-mannopyranosyl units, and one D-glucopyranosyluronic. Xanthan gum is an anionic polymer which is used for controlled delivery of active agent from a matrix system [12].

Gum karaya, sometimes called as sterculia gum is a complex water-soluble polysaccharide. It is a hydrophilic colloid prepared from the exudates of *Sterculia urens* tree.

**Table 1** Corresponding $T_p$s and enthalpy values of biomaterials

| Sample | $T_o$/°C | $T_p$/°C | $\Delta H_f$/J g$^{-1}$ |
|---|---|---|---|
| Chitosan | 50.42 | 106.41 | 278.71 |
| Psyllium husk | 81.18 | 147.17 | 595.33 |
| Pectin | 47.97 | 93.41 | 324.09 |
| Guar gum | 47.91 | 119.48 | 1010.01 |
| Xanthan gum | 47.87 | 115.31 | 1315.24 |
| Karaya gum | 47.84 | 107.89 | 908.21 |
| Sodium alginate | 47.90 | 112.44 | 1177.28 |

It is a partially acetylated complex polysaccharide composed of galacturonic acid, β-D-galactose, glucuronic acid, L-rhamnose, and other residues obtained as the calcium and magnesium salt [13–15].

Alginic acid, also called algin or alginate, is an anionic polysaccharide distributed widely in the cell walls of brown algae, where it, through binding water, forms a viscous gum. Alginate plays a better role in the design of a controlled release product. At low pH, hydration of alginic acid leads to the formation of a high-viscosity acid gel. Alginate is also easily gelled in the presence of a divalent cation as the calcium ion. Dried Sodium alginate beads reswell, creating a diffusion barrier and decreasing the migration of drug molecules [16, 17].

In the present study, thermal study of common biomaterials was evaluated by means of DSC technique (Table 1).

## Experimental

### Material

Chitosan and Sodium alginate were purchased from SD Fine Chem, Mumbai, India. Guar gum, Xanthan gum, Karaya gum, and pectin were purchased from Yarrowchem products, India. Food grade Psyllium husk was purchased from Organic India. All other chemical reagents used were of analytical grade.

### DSC analysis of biomaterials

Differential scanning calorimetry analysis was performed by DSC (Pyris-1, Perkin Elmer, USA). All samples were weighed (sample weight = 10 mg) into aluminum DSC pans. The sample pans were sealed and allowed to stabilize at room temperature for 24 h before heating. Thermal scans were carried out from 50 to 200 °C at a heating rate of 10 °C min$^{-1}$ using an empty pan as reference. Onset temperature (To) and peak temperature ($T_p$) were determined from the DSC curves. Enthalpy of fusion ($\Delta H_f$) was evaluated based on the area of the main endothermic peak.

## Results and discussion

Biomaterial plays a very useful role in drug development and the DSC thermal study is one of the most preferred techniques in preformulation. Thermal characterization provides general information about thermal transition, and chemical and stability properties. The morphology of biomaterial can be either amorphous or semi-crystalline, and the tendency of a biomaterial to crystallize depends on the presence of side chains.

The Fig. 1 shows a typical DSC curve of Chitosan exhibiting its $T_o$ (50.42 °C) and $T_p$ (106.41 °C). The enthalpy of fusion for Chitosan was found to be 278.71 J g$^{-1}$. The Fig. 1 also shows DSC curve of Psyllium husk mucilage

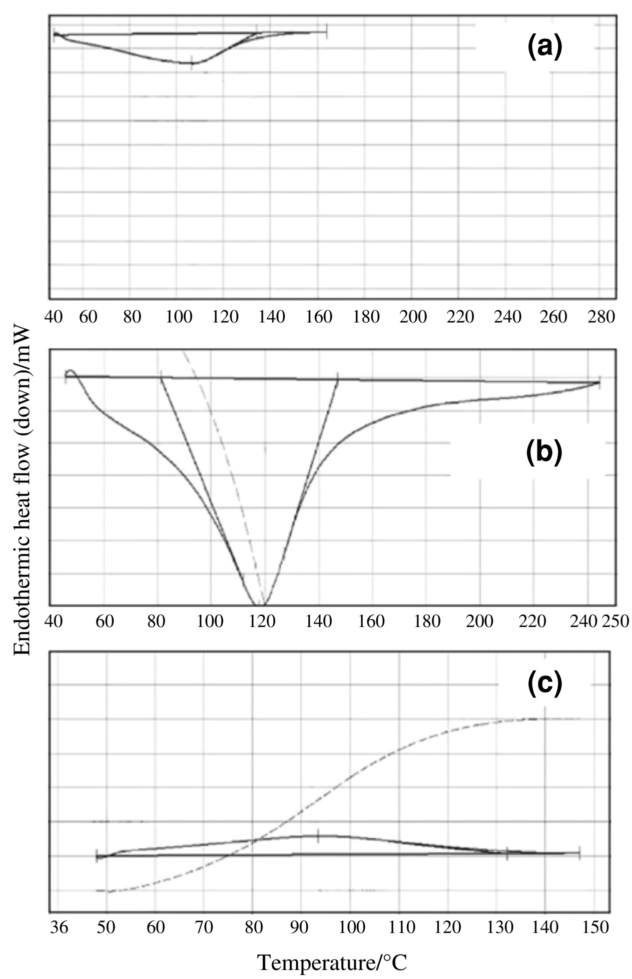


**Fig. 1** DSC curve of Chitosan (**a**), Psyllium husk mucilage (**b**) and Pectin (**c**)

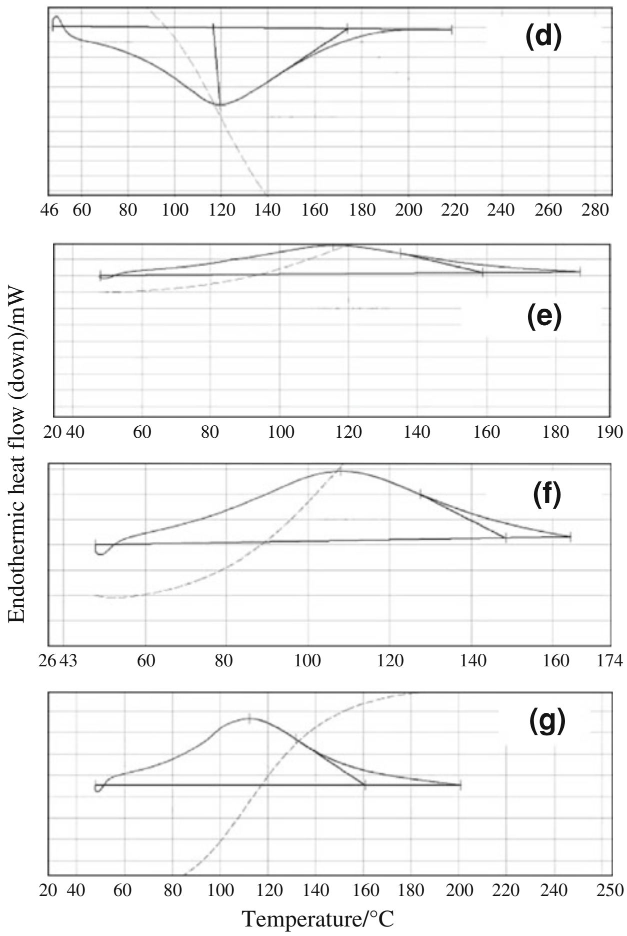


**Fig. 2** DSC curve of Guar gum (**d**), Xanthan gum (**e**), Karaya gum (**f**) and Sodium alginate (**g**)

at 81.18 °C ($T_o$) and 147.17 °C ($T_p$). The endothermic peak for Psyllium husk was found to be 595.33 J $g^{-1}$. The DSC curve of Pectin showed $T_o$ at 47.97 °C, while $T_p$ at 119.48 °C, as shown in Fig. 1. The enthalpy value for Pectin was found to be 324.09 J $g^{-1}$. 47.91 °C ($T_o$) and 119.48 °C ($T_p$) with enthalpy value of 1010.01 J $g^{-1}$ was observed for guar gum, as shown in Fig. 2. Fig. 2 also shows a typical curve of Xanthan gum exhibiting its $T_o$ (47.87 °C) and $T_p$ (115.31 °C). The enthalpy value for Xanthan gum was found to be 1315.24 J $g^{-1}$. Fig. 2 shows DSC curve of Karaya gum at 47.84 °C ($T_o$) and 107.89 °C ($T_p$). The enthalpy value for Karaya gum was found to be 908.21 J $g^{-1}$. The typical DSC curve of Sodium alginate is also shown in Fig. 2. It shows its $T_o$ at 47.90 °C and $T_p$ at 112.44 °C. The enthalpy value for Sodium alginate was found to be 1177.28 J $g^{-1}$.

## Conclusions

In recent years, biomaterials, especially polysaccharides and natural gums, were well explored for various pharmaceutical function like binder, disintegrant, matrix former, and for other novel functionality. The seven biomaterials explained above were well utilized in pharmaceutical formulation development. This study will help the future researchers to choose these biomaterials for their specific application in drug development.

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