Multiresponse modelling of the caramelisation reaction

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Caramelisation is the common name for a group of reactions that occur when carbohydrates are exposed to high temperatures. These reactions differ from Maillard reaction, since no amino groups are involved. They often occur during the preparation of traditional sugar syrups and caramels, which are extensively used in confectionery and pastry products.

The use of high temperatures in the preparation of traditional sugar syrups leads to sucrose hydrolysis into fructose and glucose, which are further degraded into weak acids, oligosaccharides and polymeric products and aromatic compounds, such as hydroxymethylfurfural (HMF) and 2-furaldehyde (furfural).

The objective of this work was to develop mathematical mechanistic models that describe sucrose thermal degradation and caramelisation products formation, using multiresponse modelling regression schemes.

Isothermal experiments were performed using different initial sucrose concentration (70 to 97 (w/w %)) at different processing temperatures (100 to 180ºC). Sucrose degradation and products formation were assessed using HPLC.

Under the conditions used to prepare the traditional sugar syrups and caramels, commercial sucrose is heated with small amounts of water in order to attain supersaturated (at room temperature) solutions. Undesuch conditions, a lag phase in sucrose thermal degradation was experimentally observed. This lag phase was also observed in the formation of reaction products, and can be interpreted has an autocatalytic nature of sucrose hydrolysis.

This research work proposes a kinetic model, using a multiresponse approach, for the caramelisation reaction that was able to describe both the lag and exponential phases of the experimental data. The complexity of the caramelisation reaction makes the use of multiresponse modelling very attractive, since it allows using simultaneously the information of both sucrose degradation and products formation in order to obtain more realistic models and consequent insightful parameter estimation.

Keywords: Multiresponse modelling, sucrose thermal degradation, caramelisation reaction, autocatalytic behaviour