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MICROWAVE PROCESSING IN SINGLE MODE CAVITIES

SEAWEED PROCESSING USING INDUSTRIAL SINGLE MODE CAVITY MICROWAVE HEATING

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The purpose of this study is to develop a clean chemical extraction technique based on industrial microwave heating technology. The performance of microwave assisted extraction ("MAE") will be assessed using a carefully designed experimental set-up with a potential for scaling up in chemical processing applications.

Microwave processing of materials is a relatively new technology that provides alternative approaches for enhancing material properties. It provides several advantages through savings in energy, space and time; a reduction in the environmental impact of material processing and an opportunity to produce new materials and microstructures that can not be achieved by other methods. Advantages in utilising microwave technologies for processing materials include penetrating radiation, controlled electric field distribution and selective and volumetric heating[1].

Carrageenan is a generic name for a family of natural, water-soluble, sulphated galactans that are isolated from red seaweed and exploited on commercial scale. The three main commercial carrageenans are: ι - (iota), κ- (kappa) and λ- (lambda). Its functions include fat, foam and emulsion stabilization, gelation, and thickening. It is resistant to shear degradation, lubricates particulates and has excellent shear thinning characteristic. Alkaline modification is produced through the acclimation of the α-D-galactose-6 sulfate and 2,6-disulphate units to the corresponding 3,6-anhydro derivatives in strong alkaline media. The 3,6-anhydro bridges are formed by the elimination of the sulphate from the C-6 sulphate ester of the precursors and the concomitant formation of the 3,6-anhydro bridge. This formation is based on a two-step mechanism. First, the α-linked galactose 6-sulphate (D6S) converts from the $^4C_1$-conformation (equatorial 6-O-SO_3^--Gal) into the $^1C_4$-conformation by the increase in temperature. This puts both the 6-O-SO_3^--Gal and the C3-OH into an axial position. The strong alkali present simultaneously ionises the free hydroxyl groups (at C-2 and C-3 in κ-carrageenan; at C-3 in ι-carrageenan) of the $\alpha(1\rightarrow4)$-linked D-galactopyranose. The second step is the nucleophilic displacement reaction of C6-sulphate resulting in the formation of the 3,6-anhydro bridge in the same galactose residue (DA) and the release of the sulphate group at C-6.

In this study a microwave-assisted extraction technique is developed to optimize the extraction of iota carrageenan from *Eucheuma denticulatum* and kappa carrageenan from *Kappaphycus alvarezii*. Typically, viscous materials such as carrageenan, transfer energy poorly. With conductively heated vessels, pyrolytic degradation on the walls can co-occur with incomplete reaction towards the center of the container. Large thermal gradients can result in sub-optimum conversions, loss of product and laborious clean up procedures. In addition when high temperatures are required, heat losses increase and conductive heating becomes inefficient. Under microwave conditions these problems are diminished[2].

The conventional method of commercially producing carrageenan is by extracting the polysaccharide from the seaweed with 0.05 -0.1 N sodium hydroxide or calcium hydroxide at 90-100^{o} C for 3 to 5 hours. A new cost-effective process has been developed whereby the extraction process is reversed from that used in making filtered carrageenan. Instead of extracting the carrageenan into solution, the carrageenan is kept in the swollen gel state as it exists in the seaweed and most of the non-carrageenan substances are extracted from it, most that is except for 10% to 15% insolubles that are more than 90% algal cellulose. This is done by subjecting the seaweed directly to a strong alkali (2.0 N KOH) extraction at 70^{o} - 80^{o} C. The conditions prevent the carrageenan from dissolving but allow cellular debris of low molecular weight to be removed in the solution. Both products from the two methods of extracting carrageenan have been approved for food use in U.S.A and Europe and the European Commission Specifications for Food Additives distinguish between these two commercially available carrageenans by using E407 for carrageenan A and E407a for carrageenan B (using the new method).

With the proposed method, the feasibility of extracting a polysaccharide (commercially known as carrageenan) using microwave irradiation will be examined. The innovative method that will be developed in this study is based on the use of extraction solvents that are fully or partially transparent to the microwaves as compared to the target material. This allows for selective and localised heating within the material without requiring excessive energy to heat the complete mixture. A single mode system is used to study the influence of solvent, irradiation time, microwave power, temperature and effect of sample matrix characteristics on carrageenan yield and purity. This research attempts to compare the thermal kinetics to the kinetics in a microwave field as well as establish structure/microwave processing relationships. The understanding which is obtained from this research will eventually lead to the design of molecules with specific microwave-absorbing features for particular end-use applications.

REFERENCES

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