Preparation of a 'honeycomb'-gel bioreactor

A RATHJEN, M HASCH, B KAEMPF, TH WEISBRODT and W E L SPIESS
Institute of Process Engineering, Federal Research Centre for Nutrition, Karlsruhe, Germany

1. SYNOPSIS

Viscosity, melting point and firmness were measured with the aim of optimizing the recipe for a κ-carrageen block combining a maximum of gel firmness with a minimum of time-temperature stress to the microorganisms to be included. A preparation of κ-carrageen (30 g l^{-1}) and potassium chloride (c[K^+] = 2 g l^{-1}) has been found to be an acceptable compromise between these conflicting requirements.

2. INTRODUCTION

Biocatalysts are gently immobilized when enzymes or whole cells are included into a gel matrix of polymers or polysaccharides (1). A block of gel, pierced by many drilled holes (Fig. 1) has been found to have several advantages over the usual pellet shaped immobilisates (2). To produce a gel-block bioreactor of this kind the bacterial suspension is homogeneously mixed with the liquefied κ-carrageen gel at about 40 °C, poured into the mould and cooled down quickly. The firmness and melting point of the κ-carrageen used, because of its extremely low natural potassium content, are influenced by addition of potassium ions. When a gel-block bioreactor is produced on the laboratory scale, the viscosity of the liquefied gel is an essential criterion, because it determines the distribution of microorganisms and the mechanical suitability of the set gel.

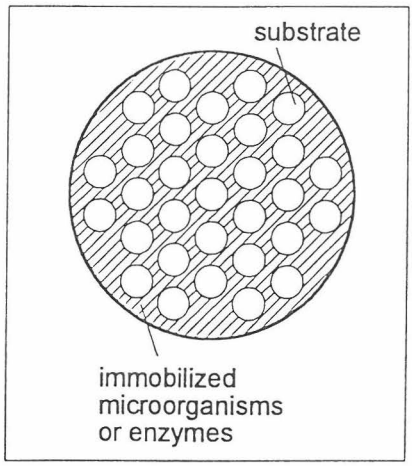

Fig. 1 Gel-bioreactor (cross-section)

3. MATERIAL AND METHODS

The viscosity of aqueous κ-carrageen solutions (Copenhagen Pectin Inc., type X 0909) as a function of temperature has been investigated using a coaxial cylinder viscosimeter (HAAKE, Rotovisko RV 12) at a shear rate of about 200 s^{-1}. Solidification temperature and characteristic viscosity were defined as indicated in Fig. 2.

Compression and relaxation experiments on a cylindrical specimen were conducted to determine its plastic and elastic properties. The plasticity of the gel was expressed as the ratio of initial to remaining force after relaxation after PELEG (3).

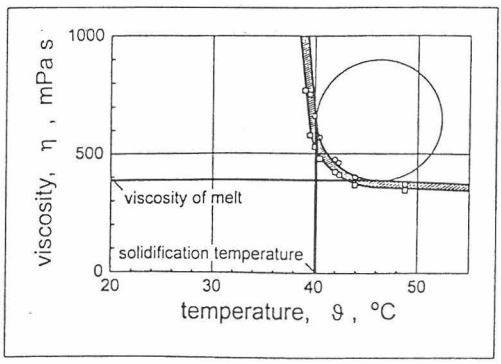

Fig. 2 Solidification temperature and viscosity of the liquefied gel

4. RESULTS

Viscosity and firmness characteristics were as shown in tables 1 to 4. The viscosity of melt was measured at a temperature of about 10 centigrades above the solidification temperature (see Fig. 2); elasticity modulus and plasticity ratio were determined at room temperature.

Table 1
Solidification temperature, ϑ , °C

potassium g l^{-1}	κ-carrageen, g l^{-1}		
	20	30	40
1	27	34	48
2	36	40	50
3	46	46	55

Table 2
Viscosity of melt, η , mPas

potassium g l^{-1}	κ-carrageen, g l^{-1}		
	20	30	40
1	64	380	487
2	71	384	532
3	79	389	578

Table 3
Elasticity modulus, E , kPa

potassium g l^{-1}	κ-carrageen, g l^{-1}		
	20	30	40
1	28	63	93
2	50	86	117
3	63	99	122

Table 4
Plasticity ratio, a

potassium g l^{-1}	κ-carrageen, g l^{-1}		
	20	30	40
1	0.68	0.43	0.28
2	0.59	0.37	0.21
3	0.51	0.38	0.25

Firmness of the gel, in terms of elasticity modulus and plasticity ratio, increases with increasing solidification temperature. Depending on the microorganisms to be included, immobilization temperatures should not exceed 40 °C. Under laboratory conditions, where the preheated suspension of liquefied gel and microorganisms is poured into the mould, viscosity of the melt should not exceed ca. 500 mPas to avoid inhomogeneities in the 'honeycomb'-gel block.

5. CONCLUSIONS

The mechanical properties of low-potassium κ-carrageenan gels may be changed simply by changing gel concentration and/or the amount of potassium ions added. The gel/potassium ratio finally employed was selected from the point of view of minimizing the thermal stress on the microorganisms to be immobilized in the gel bioreactor.

6. REFERENCES

(1) W HARTMEIER: Immobilized Biocatalysts. Springer Verlag Berlin, 1988

(2) M WILK, A RATHJEN and H SCHUBERT: Microbial denitrification using membrane reactors and a novel gel-immobilization technique. TU 267, Volume II.
6th European Congress on Biotechnology, Firenze, 13-17 June 1993

(3) M PELEG: Characterization of the stress relaxation curves of solid foods. J. Food Sci. 44 (1979) 277-281