Bulletin of Electrochemistry 7 (6) June 1991, pp 269–270

0256-1654/91/$ 3-50

BIPOLAR FLOW CELL FOR THE PRODUCTION OF CALCIUM GLUCONATE

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[Received: 1991 March; Accepted: 1991 April]

A prototype Bipolar Flow cell (BFC) of 500 amperes capacity has been developed for the production of calcium gluconate. The new cell design enables attainment of 30-40% savings on energy consumption, compared to the existing process with tank cells. Design features of the BFC are discussed and process data is reported for the production of calcium gluconate with the new cell design. A comparative evaluation of the new design with the existing design is also reported for the production of calcium gluconate on the basis of process parameters.

Key words: Bipolar flow cell, calcium gluconate, Br_2 (or) $HOBr/Br^-$ redox mediator

INTRODUCTION

The economic success of most of the electrolytic processes depends on the choice of an appropriate cell design. Bipolar stack cells are widely used for electro-organic synthesis, in view of their advantages over other divided cells of filter press or tank type. The present paper reports the operation of a prototype bipolar flow cell for the production of calcium gluconate. The design features of the bipolar cell are highlighted and a comparative evaluation is made with the tank cells used at present, with regard to energy consumption, space-time-yield etc. for the production of calcium gluconate.

The preparative and basic aspects of the electro-oxidation of glucose have been reported earlier [1-5]. Rotating electrode cell (REC) has been developed for the production of calcium gluconate with high operating current densities and high yields [6-8]. Detailed material balance studies for the process have been reported [9]. A bipolar flow cell (BFC) has been developed recently for the oxidation of glucose and preliminary studies have been carried out in the bipolar cell to optimise the process conditions [10]. The present paper reports the studies conducted on a commercial size prototype bipolar flow cell of 500 A capacity for the production of calcium gluconate.

EXPERIMENTAL

BFC used in the present studies comprises of a stack of graphite disc electrodes packed inside a PVC housing with suitable insulating spacers separating the electrodes. Electrolyte is circulated through the stack of electrodes by a centrifugal pump and electrolysis is conducted in batch mode with total recirculation of electrolyte. The cell set up is shown in Fig. 1.

Electrolyte was prepared in a stainless steel jacketed vessel by dissolving glucose and sodium bromide in deionised water to the required concentration. Electrolysis was conducted till the required concentration of calcium gluconate was built up in the electrolyte. Temperature of electrolysis was maintained within limits by circulating water through the jacket of the storage tank. At the end of electrolysis, the product was isolated by cooling the electrolyte in a crystalliser and the mother liquor was recycled to the electrolytic cell. The calcium ion content and bromide ion content in the electrolyte were estimated by titrimetry. The electrolytic cell was continuously operated with reuse of electrolyte to collect process data for the production of calcium gluconate.

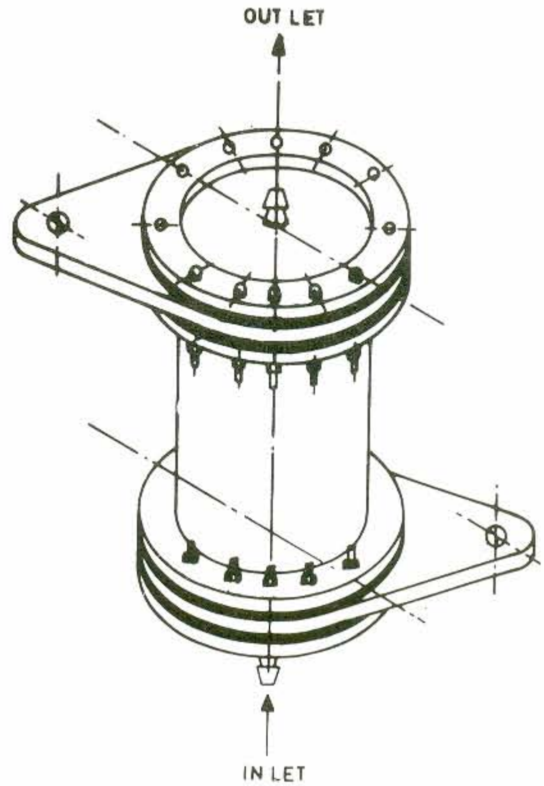

Fig. 1: Bipolar flow cell

DESIGN PRINCIPLES

The design requires a base graphite plate. A stack of graphite disc electrodes rest on the base plate. The electrodes are separated from each other by suitably positioned insulating spacers. The electrolyte inlet is in the bottom plate and the outlet in the top plate. The compact design gives a high electrode surface to volume ratio of 174 m^2/m^3 and therefore a high space-time-yield of 0.1 to 0.2 $kg.hr^{-1}$ 1^{-1}. Thus the space requirements are small.

RESULTS AND DISCUSSION

The process data for the production of calcium gluconate using BFC is given in Table I. The results show that the voltage is brought down to 3.0–4.0V as compared to 10–11V with REC. Thus the energy consumption is only 1.3 to 1.8 kwh. kg^{-1} of calcium gluconate which is about 40% less than that with REC.

TABLE-I: Process data for the production of calcium gluconate with BFC

Bipolar graphite electrodes	26 (30 cm dia)
Inter-electrode gap	1-2.5 mm
Electrolyte	2% NaBr solution
Voltage (V)	3.5 - 4.0
Current density ($A.dm^{-2}$)	3-5
Current efficiency (%)	70-80
Material yield (%)	80-90
Energy consumption for electrolysis (kwh. kg^{-1})	1.3-1.8

In addition the cell itself is less expensive. The investment cost is dependent on the electrode material used. Unlike REC where mercury cups are used for electrical connections, BFC is connected to rectifier by suitable busbars and as operating currents are low in BFC, busbar costs are also low. It is easy to remove and replace the electrodes in the stack. Since the cell voltage is low in BFC, the heat to be removed is also low. Thus tap water is used for cooling the electrolyte in BFC thereby avoiding the investment and operating costs of the refrigeration unit.

COMPARATIVE EVALUATION OF BFC AND REC

The comparative features of the REC and BFC are given in Table II. It is seen that 35–50% energy savings are achieved with the use of BFC, as a result of lower cell voltage. Other advantages of the BFC include high electrode area per unit volume, high space-time-yield, lower investment costs, continuous operation, easy maintenance and modular design.

TABLE-II: Comparative operating characteristics of REC vs BFC

Operating parameters	REC	BFC
Area of electrode per unit volume (Cm^{-1})	0.04	1.71
Inter-electrode distance(mm)	10	1 - 2
Electrical connection	Through mercury	Direct
Mechanical problems	Wobbling may arise	No mechanical problem
Cell components	Not standardised and hence replacement difficult	Standardised and replacement of electrodes is easy
Cooling	Refrigerated water or brine solution with PVC cooling coils	Cooling of electrolyte is done outside the cell with ordinary water
Cell voltage (V)	10 - 11	3.5 - 4.5
Energy consumption (kwh. kg^{-1})	2.6 - 2.8	1.3 - 1.8 (Saving achieved = 35-50%)
Space time-yield ($kg. hr^{-1}.l^{-1}$)	0.01	0.16

CONCLUSION

A biplar flow cell of 500 A capacity has been developed for the production of calcium gluconate. The new cell design enables attainment of 35–50% energy savings for the process as compared to the tank cells used at present. Other advantages of the new cell design include simple cell design, low investment costs and high space-time-yields.

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