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FERMENTATION PRODUCTION OF BUTANOL AS AN ALTERNATIVE BIOFUEL. PROCESS APPRAISAL.

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Introduction. Butanol belongs to bulk chemicals which could be produced via fermentation. Nowadays it attracts a special attention because of its very good properties as a fuel. In contrast to ethanol it is well miscible not only with gasoline but also with diesel fuel. History of its microbial synthesis is very long dating back to Louis Pasteur. Industrial production butanol went through its several up-and-downs. The last but very intensive boom started very recently connected with energy crisis and with search for alternative fuels and energy sources [1, 2].
Objective of our presentation is to introduce a brief engineering analysis of the process critical points (incl. waste processing) made on the basis of our present laboratory investigation, current state of the art and industrial results (fermentation plant was built in Czechoslovakia in the sixties of the last century and operated 5 years).

Methods. Various strains of genus *Clostridium* were tested (soil isolates, cultures from international and national culture collections): *Clostridium pasteurianum, C.acetobutylicum, C. saccharoperbutylacetonicum*, *C. saccharobutylicum*, *C. beijerinckii* and *C. tetanomorphum.* Cultivation tests proceeded in test tubes or in Erlenmeyer flasks either in the anaerostat or in the anaerobic chamber at 37 or 30 ^{0}C. Main cultivations were carried out in the fermentor (B.Braun, Biotech) of working volume 3.0 L. Batch, fed-batch and continuous cultivations of various modifications were carried out. Several types of cultivation media were investigated to find the most suitable type with optimal technological properties (molasses, potatoes, grain, corn, cellulosic glucose, TYA and media prepared by different hydrolytic procedures from corn stover, DDGS etc.). In order to increase the productivity of the butanol biosynthesis and to decrease the inhibitory effect of butanol a few down-stream processes were integrated with fermentation (gas stripping, adsorption). Substrate and product concentrations were determined by HPLC. Gaseous products H_2 + CO_2 were determined by GC.

Results and discussion. Only a few strains of clostridia succeeded to grow efficiently in most of media. Even xylose has been proved to be a convenient carbon source for most of the solvent producing clostridia, however, its utilization had to be used together with at least small amount of more easily utilized carbon source. Main results and comparison with literature data are demonstrated in *Table I.*

Table I Comparison of results

Ref	B [g/L]	A [g/L]	E [g/L]	B/A	$Y_{B+A+E/S}$	p_B [g/L/h]
[2]	~ 19	~ 5	1,3	3.8	~ 0.33	0,1–0,4
[3]	~16	~ 6	~ 2.2	2.7	~ 0.35	~ 0,4
[4]	~19	4	2-3	4,7	~0.37	0,35-0,45
[5]	~ 5*	1.3*	0.43*	3.8	~0.41	0.98

B…butanol, A…aceton, E…ethanol, [2] ... ref. (Blaschek, 2002), [3]…results from the industrial scale obtained in 1955 – 1962 in Czechoslovakia, [4]...batch laboratory results of the authors, [5] ... fed-batch laboratory experiments with solvent stripping by a fermentation gas (authors´ results), * after stripping

Conclusions. Our results and results of many authors give evidence that for an effective and economically acceptable production of bio-butanol it is necessary to develop technological procedure with a strict respect to microorganism used (if available a stable genetically modified culture with higher tolerance to butanol and phage resistance, low sensitivity to degeneration) and to raw materials (optimized fermentation media). Due to relatively low concentration of butanol in fermentation broth and its high toxicity it necessitates to integrate this fermentation process with one of highly efficient, technically feasible, energetically less demanding separation process (e.g. adsorption, pervaporation, gas stripping, pertraction).

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