Vladimir V. Zverlov, Galina A. Velikodvorskaya, Wolfgang H. Schwarz

Institute of Molecular Genetics RAS, Kurchatov Sq. 123182 Moscow, Russia, and Research Group Microbial Biotechnology, Technical University Munich, Am Hochanger 4, D-85350 Freising-Weihenstephan, Germany
e-mail: zverlov@hotmail.com

Bacterial acetone-butanol production in the former Soviet Union

Introduction

A major part of the technically important acetone, butanol and ethanol (ABE) during the first half of the 20th century was produced by bacteria. Unfortunately, most of the information on the production processes and most of the valuable, carefully selected industrial strains (*Clostridium acetobutylicum*, *C. beijerinckii* and others) seem to be lost. Unlike in the Western countries, where the Weizmann process was given up shortly after the Second World War, in Russia this biotechnological process may have been extensively run up to the late 60ths or even beyond. This process is again in the focus for the production of solvents for energy or chemical feedstock from **agricultural material**.

After the Perestroika the archives in the Soviet Union became accessible and the details on the Russian Weizmann process can now be investigated as it was actually run. A preliminary compilation of the data obtained so far is presented, including data on the scale of the process and the fermentation technology and microbiology used. Surprisingly, a mixture of starch and molasses was used as substrate. At least one production plant seems still to be running on a large scale.

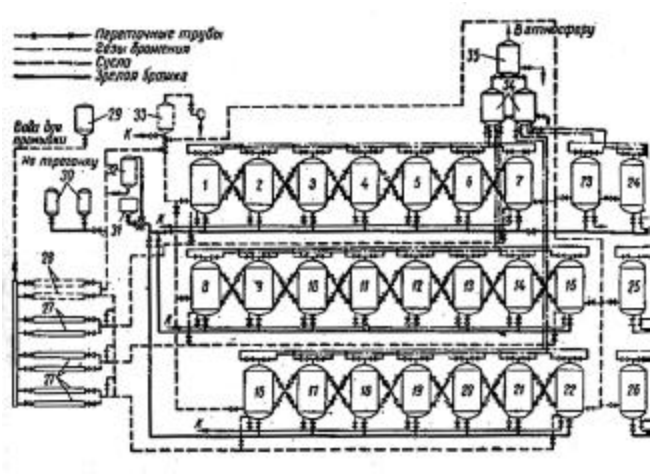
A list of production plants for ABE fermentation in the former Soviet Union

9 different industrial-size plants for the production of **acetone** and **butanol** from agricultural material have been found to be reported in Russian literature:

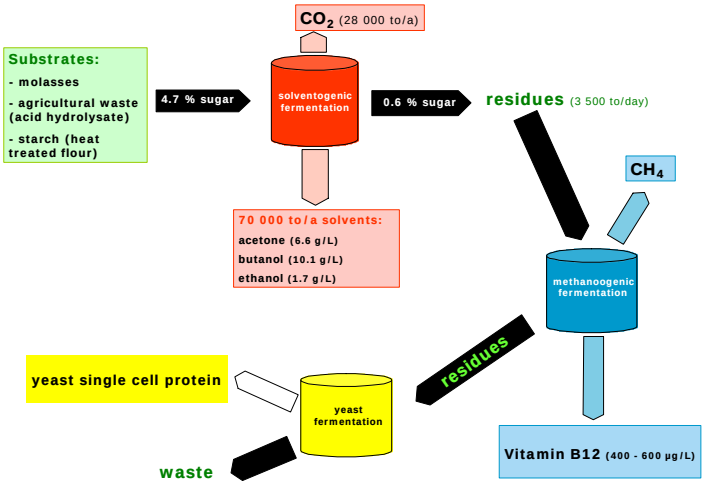
Name of plant	Data available from	Comment
Dokshukinski	1961, 1969	flour / molasses (30:70); well documented process (see below)
Evremowski	1982	
Grosnyinski	1962	Demonstration plant for continuous process in 1939
Nartkalinski	1962, 1975, 2003	molasses
Petrovski	1975	
Metrofanovski	1975	
Michurinski	1975	
Bulchovski	1975	potatoe starch

An example plant

Schematical presentation of the acetone-butanol production line: the substrate passes 3 parallel lines of 7or more fermenters each (#1-26). The preculture fermenter is #33, the feeding fermenters are #30. #27/28 are substrate coolers. CO_2 is collected in #34/35. At the time of description in 1975 this plant has been run successfully for 10 years.



Flow chart of the *Dokshukinski* process:



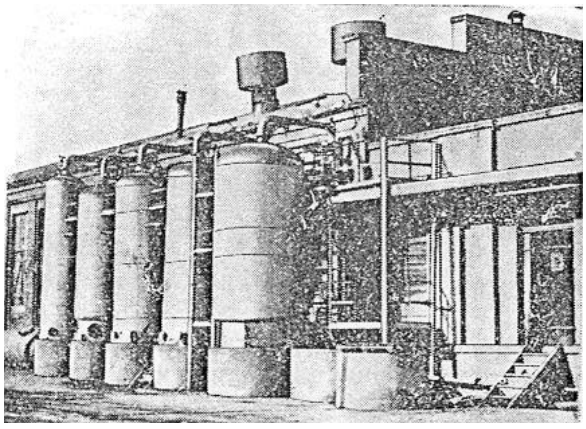
It was reported that at the ***Dokshukinski*** plant the solvent production was transferred to a continuous process in 1960. But the plant was working much earlier, probably since the 2nd World War. In 1961 the substrate was modified from pure flour hydrolysate (wheat and/or rye) to a mixture of flour (heat treated) and molasses (30:70). Additionally, an acid hydrolysate from corn stubbers was also used (sulfuric and phosphoric acid 3:1 or 4:1).

Efficiency: 50 % of the substrate sugars were converted to CO_2, and 33-39 % to solvents (60 % of that was butanol), leading to a yield of 9 tons solvents per 100 tons grain. By-products were CO_2, vitamin B_{12} and yeast protein for feed. The production of methane gas provided the energy for running the process.

Summary

The results from this literature survey show that the bacterial acetone-butanol production process was extensively used in the Soviet Union up to the 80s and surprisingly is running even now as a large scale continuous process where favorable local circumstances allow (e.g. the ***Nartkalinski*** plant). The long-time experience with this obligatory sterile process at a large scale and with well adapted bacterial strains may be used for establishing a similar process at a local basis in Western Europe, if modern process technology (esp. for product recovery) were combined with the use of cheaper substrates such as waste material from agriculture or food industry.

More archival studies have to be done in Russia, especially on the strains and the technical processes used. The production strains should be obtained and their production potential investigated in the light of the present-day needs for modern biotechnological processes.



Photography of the Dokshukino plant in 1969