

Organic Synthesis Industry: Yesterday, Today, Tomorrow

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The organic synthesis industry belongs to the most important branches of the modern chemical industry. Its significance is conditioned by manufacturing chemical products necessary for the production of polymers, chemical fibers, resins, dyes, pesticides for agriculture and other compounds without which the progress of many industrial branched is impossible.

For the middle of the last century practically all organic compounds were obtained from raw plant and animal materials. Today carbon-containing products (natural and associated gases, oil-refinery gases, coke gases, crude oil, etc.) are the main source for the production of various organic compounds.

The organic compounds obtained via synthetic methods may fully substituent the natural materials. Moreover, they have the valuable properties which are absent in natural compounds. At the same time the synthetic methods do not exclude the possibility of using products of plant and animal origin as raw materials.

Black coal was the main raw material at the beginning of organic synthesis development. Drugs, dyes, explosives, etc. were produced from coal tar pitch obtained while coking. The peculiarity of the industrial processes in the end of XIX century was the use of liquid phases, low temperatures and pressures as well as non-catalytic systems.

Black coal as the main raw material for the organic synthesis industry dominated in Western European countries in 20-50th of the past century. Among main directions of its application were:

- production of aromatic hydrocarbons from coal tar pitch;
- production of methanol from syngas;
- production of motor fuels via coal hydrogenation and from syngas via Fisher-Tropsch method;
- production of acetylene from calcium carbide and obtaining of acetic aldehyde and acid, vinylchloride, vinylacetate, acrylonitrile, acrylic acid and other products based on acetylene.

It should be also noted that the rapid growth of organic synthesis industry was also provided by numerous scientific-technical achievements at the beginning of XIX century. The most important were the development of thermal cracking and oil pyrolysis, natural gas processing, production of calcium carbide. These processes supplied the organic synthesis industry by olefins and acetylene, i.e. by main primary products. Using catalytic systems accelerated and simplified the most of multistage methods. The development of distillation and sorption theory gives the possibility for the development of clear rectification methods for polycomponent mixtures.

In 60th of the past century the liquid hydrocarbons plants were closed from the ecological point of view. During this period oil and natural gas took priority as raw materials for the organic synthesis industry. They became dominant due to the high content of hydrogen in their structures and low cost of their processing compared with coal.

With the development of the organic synthesis industry the application of main products was reoriented. If phenol was earlier used for the disinfection only, now it is used for the production of synthetic

resins, dyers, drugs, synthetic fibers, etc. Ethyl alcohol is used for the production of synthetic rubbers. Till recently phthalic anhydride was the raw material for the production of dyers and now it is used to produce plastic mass and plasticizers.

The need in great amount of cheap drugs, dyers, plastic mass, resins and chemical fibers causes the development of new methods of semi-products production, what in its turn, intensifies both scientific investigations and the organic synthesis industry.

On the other hand, the following tendency is observed: edible raw materials (products of plant and animal origin) for technical needs are exchanged for hydrocarbon products obtained from natural gas, coal tar pitch and oil. Thus, starch- and sugar-containing products (seeds, potatoes), fermentation of which results in alcohols, acetone and lactic acid, are exchanged for ethylene. For the synthesis of soap and glycerin the paraffin and propylene, respectively, are used instead of natural fats.

To simplify the chemical synthesis methods the new discoveries in the sphere of catalysis theory and methods, as well as the use of photochemical processes, initiators, high pressure and ultrasound are of top priority.

The basis of modern organic synthesis industry is oil and natural gas. Around 96% of all organic products throughout the world are obtained from oil and gas. Moreover, the most of them are produced from ethylene and the rest – from propylene, butadiene, aromatic hydrocarbons and methanol.

Ethylene, as a primary petrochemical product is produced from oil and used for the production of polyethylene, propylene oxide, ethylene glycol, ethylbenzene, acetic anhydride and acid, vinyl chloride, vinyl acetate, etc.

Propylene is used for the production of polypropylene, propylene oxide, isopropanol, acrylonitrile, cumene, butadiene, etc.

The further important direction of natural raw material processing is the production of aromatic hydrocarbons from oil, mainly benzene, toluene, xylene and naphthalene. Earlier these products were obtained via black coal thermal decomposition; nowadays catalytic reforming and oil pyrolysis are for this purpose.

In recent years the increased interest to syngas ($\text{CO} + n\text{H}_2$) is observed. Syngas is obtained from natural gas and may be the raw material for hydrocarbons and methanol production via Fisher-Tropsch

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method. Methanol is a semi-product for the synthesis of formaldehyde, acetic acid and anhydride and even aromatic hydrocarbons.

Acetylene is also a semi-product of the organic synthesis industry. It is the source of acetic acid and aldehyde, vinyl chloride and vinyl acetate, chloroprene, acrylic acid and its esters. But every year the role of acetylene as a raw material decreases because the production of above-mentioned products on the basis of ethylene is cheaper.

Today there are four main directions in the organic synthesis industry:

1. Physico-chemical processing of natural raw materials (e.g. oil distillation and refining, obtaining and processing of coal raw materials, sugar production from sugar-beets, etc.).

2. The main (heavy) organic synthesis (production of ethylene, methanol, benzene, butadiene, etc.).

3. The fine (light) organic synthesis (production of drugs, dyes, chemical reagents, etc.).

4. Physical processing of chemical products and semi-products (production of powdered detergent, photomaterials, plastic mass, paints and lacquers).

Among all listed directions the main organic synthesis has the priority because it involves the production of primary (ethylene, propylene, aromatic hydrocarbons) and secondary (ethylene and propylene oxides, vinyl chloride, vinyl acetate, styrene, maleic anhydride) petroleum compounds and polymer products on their basis (plastic mass, rubbers, chemical fibers). At the same time physico-chemical processing of the natural raw materials (of plant and animal origin) is still actual and important for oil and natural gas.