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The chemistry of C_1 compounds

The one-carbon compounds, in the first place methane and carbon oxides, belong to the class of the commonest and most available carbon-containing substances. C_1 compounds are used widely as raw materials in many large-scale chemical manufacturing processes (the preparation of hydrogen and the synthesis gas, hydrocyanic acid, methanol, formaldehyde, acetylene, carbon disulphide, etc.). Vigorous research directed towards the improvement of these industrial processes is being prosecuted at the present time.

New reactions of C_1 compounds (oxidative condensation of methane, carbonylation reaction, and syntheses based on a mixture of carbon monoxide with hydrogen, on methanol, and on formaldehyde) are very promising. It is to be expected that new non-traditional industrial methods for the synthesis of valuable organic substances from natural gas and carbon will be devised on the basis of these reactions. These methods may prove to be an alternative to modern petrochemistry.

This issue contains reviews on both aspects of this field.

Among C_1 compounds, carbon monoxide is used most widely in chemical synthesis at the present time. It is employed as the raw material for large-scale industrial processes such as the synthesis of methanol, the preparation of hydrogen as a result of the conversion of CO by water vapour, the preparation of hydrocarbons and higher alcohols, carbonylation and hydroformylation reactions, etc.

The synthesis of methanol

The present state of research into the physical chemistry of the synthesis of methanol (catalysts, kinetics, and process mechanisms) is analysed in the review "Modern Problems in the Synthesis of Methanol". Certain new aspects of this problem are also dealt with in the review "Catalytic Chemistry and Technology of C_1 Compounds". This review deals with new approaches to the synthesis of catalysts for processes involving the manufacture of methanol and the conversion of CO by water vapour based on the anionic modification of oxides. In addition, it describes a new principle governing the synthesis of methanol under artificially created non-stationary conditions, which make it possible to increase the degree of conversion of the raw material with the simultaneous reduction of the requirement for metals in the apparatus.

Syntheses of other organic compounds from carbon monoxide and dioxide

In connection with the search for alternative sources of raw materials, research into the synthesis of other organic compounds from CO and hydrogen has been reactivated in recent years.

The mechanisms of the synthesis of hydrocarbons and oxygen-containing compounds from CO and hydrogen are subjected to a general analysis in the review "Development of Ideas about the Mechanism of the Fischer–Tropsch Synthesis".

The review "The Role of the Adsorbed Forms of Hydrogen and Oxygen in the Reactions of Oxygen-containing One-Carbon Molecules on Membrane Catalysts" deals with a novel method for the hydrogenation of CO under conditions where hydrogen diffuses through a palladium-containing membrane. The analogous carbon dioxide hydrogenation reaction is also considered in the same review. The possibilities for the involvement of carbon dioxide in chemical syntheses, including its use in electrocatalysis, are also analysed in the review "Catalytic Chemistry and Technology of C_1 Compounds".

A new field where carbon monoxide is used in chemical synthesis comprises the carbonylation and hydroformylation reactions. The prospects for the preparation of various classes of organic compounds (carboxylic acids and their anhydrides, hydroxyacids, lactones, ethers and esters, aldehydes, and ketones) by catalytic carbonylation are analysed in the review "Catalytic Synthesis of Organic Compounds by the Carbonylation of Unsaturated Hydrocarbons and Alcohols" by A L Lapidus and S D Pirozhkov. (The review will be published in the February 1989 issue).

The review "Preparation of Ethylene Glycol from Formaldehyde" is devoted to a detailed analysis of one of the most important hydroformylation reactions—the synthesis of glycolaldehyde (an intermediate in the synthesis of ethylene glycol).

A series of new catalytic reactions of carbon monoxide and formaldehyde involving metal complex catalysts are described in the review "Catalytic Chemistry and Technology of C_1 Compounds".

Syntheses of organic compounds from methane

An important source of raw material for the preparation of organic compounds is methane. The trend in the development of methods of synthesis of organochlorine compounds from methane and the products resulting from its processing are analysed in the review "The Synthesis of Organochlorine Compounds from One-Carbon Molecules".

A recently discovered reaction involving the oxidative dehydrodimerisation of methane to ethylene is extremely promising from the standpoint of the involvement of methane in chemical syntheses. The chemistry of this process and the trends in the development of research in this field are analysed in the reviews "The Mechanism of the Partial Oxidation of Methane" and "Catalytic Chemistry and Technology of C_1 Compounds".

A new application of the vapour-phase conversion of methane in thermochemical solar energy converters is described in the review "Catalytic Chemistry and Technology of C_1 Compounds".

Overall, the chemistry of C_1 compounds is now becoming one of the most promising and vigorously developing chemical fields. Presumably, the intensive studies prosecuted nowadays will make it possible to achieve to a large extent a change-over from the manufacture of products of organic synthesis from petroleum to their manufacture from cheaper and more readily available sources—natural gas and coal.

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