

Utilization of oil hydrocarbons by micromycetes in dependence on their systematic position

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Data have been obtained on the presence of a large set of ferments in fungi which allow them to utilize complex organic compounds both of natural and synthetic origin. The attention of the investigators was attracted by the oil hydrocarbons utilization by fungi. Such an ability has been demonstrated for more than 30 genera of fungi from different systematic groups. Yeasts were most thoroughly investigated in this respect. The yeast biomass gained from oil hydrocarbons is being widely tested as additional food for poultry and stock. The carbon utilization of fungi depends on the composition and structure of the organic compound molecule. While investigating carbohydrate utilization by fungi it was established that some species possess a wide ability of carbon utilization from a large spectrum of organic compounds, at the same time there are species which take up only a definite substance. Oil hydrocarbon utilization by filamentous fungi is still but little explored.

Over 800 strains from different systematic groups, mainly *Phycomycetes*, *Ascomycetes* and *Fungi imperfecti*, were tested by us on more than 30 soil and liquid oil fractions. The data obtained proved the ability of some *Mucorales*, such species as *Mortierella alpina* and *M. hydrophila* to utilize a large spectrum of oil hydrocarbons. The hydrocarbons preferably utilized by the fungi were: hexadecane, food paraffin, mixtures of paraffins, somewhat less readily utilized were paraffin hydrocarbons, aliphatic acids (C_{17} — C_{20}), completely and partly resin-free paraffin oils; decalin, high molecular weight alcohols, various fractions of diesel fuel etc. were not taken up by the fungi. Such species as *Mortierella ambigua*, *M. verticillata*, *M. longicollis*, *M. candelabrum*, *M. parvispora*, *M. marburgensis* etc. are able to utilize only a limited number of hydrocarbons, mainly hexadecane and paraffinum durum. *M. turficola*,

M. isabellina, *M. vinaceae* are unable to take up the examined oil products.

Within the genus *Mucor* the following tendencies were noted: psychrophilic species, such as *M. globosus*, *M. jensseni*, *M. plasmaticus*, *M. kanivzevii* etc. cannot utilize oil hydrocarbons at all, while mesophilic species as *M. griseo-cyanus*, *M. circinelloides*, *M. racemosus*, *M. plumbeus*, *M. luteus* and especially the thermophilic *M. pusillus* utilize mainly hexadecane and paraffin readily.

All the examined strains of *Actinomucor*, *Zygorhynchus* and *Circinella* are rather similar as regards their relation to the hydrocarbons tested. They utilize hexadecane, aliphatic acids (C_{17} — C_{20}), paraffinum durum readily, and poorly decomposed resin-free and partly resin-free heavy and medium paraffin oils are consumed with difficulty.

For the *Absidia* genus the following tendency is characteristic: some species such as *A. butleri*, *A. blakesleeana*, *A. corymbifera* and *A. ramosa* utilize most of the hydrocarbons tested, some species as *A. spinosa*, *A. coerulea*, *A. glauca* etc. utilize mainly hexadecane, paraffinum durum, aliphatic acids and paraffin oils purified in various degrees.

All the examined cultures of *Rhizopus* are capable of utilizing only hexadecane in small quantities. *Syncephalastrum racemosum* as regards the variability and intensity of hydrocarbon utilization is similar to *Mortierella hygrophila*, it utilized almost all tested hydrocarbons. The cultures of *Cunnighamella elegans*, *C. echinulata*, *C. blakesleeana*, *C. homothallica* are highly active in utilizing all the kinds of hydrocarbons tested, especially paraffins, aliphatic acids, hexadecane, highmolecular weight alcohols.

From the genus *Aspergillus* the strains *A. flavipes*, *A. flavus*, *A. glaucus*, *A. niger*, *A. terreus*, *A. sulphureus*, *A. versicolor* were investigated. All the strains examined utilize almost all the tested hydrocarbons. They produce a negligible biomass and an enormous number of conidia in superficial and submerged cultivation, the utilization coefficient being 50—70%. *A. terreus* and *A. sulphureus* have the widest spectrum of hydrocarbons utilization. The thermophilic species are of special interest. *A. fumigatus* utilizes paraffin at 54—56°C, *A. oryzae* at 45°C, that is at the temperature of paraffin melting what simplifies the fermentation process.

The fungi of genus *Fusarium*, possessing a large set of ferments are of a special interest for investigation of many theoretical and practical problems connected with hydrocarbon utilization. Over 300 strains of *Fusarium* from different systematic groups were examined by us, namely: *F. moniliforme*, *F. oxysporum*, *F. gibbosum*, *F. semitectum*, *F. sporotrichiella*, *F. javanicum*, *F. solanum*, *F. lateritium*, *F. avenaceum*, Utilization of the majority of the hydrocarbons tested with the exception of

cyclic compounds was characteristic for these cultures. From among unsaturated hydrocarbons, liquid and hard paraffins, heavy and medium paraffin oil and secondary aliphatic alcohol (37°C) are utilized best. The majority of the active strains belong to the species *F. moniliforme*, *F. oxysporum*, *F. gibbosum*.

The principal possibility of hydrocarbon utilization by *Penicillia* species has been reported by Tausson (1939), Beershtecher (1954), Foster (1962) and others. But in the literature data are almost absent on the hydrocarbon of definite species of *Penicillium*, so that it is impossible to compare the results of experiments and of practical application. We examined over 200 strains of 52 species of *Penicillium*. All the species were able to utilize hydrocarbons as the only source of carbon, and many of them were active towards 10—20 kinds of the oil hydrocarbons tested. In the *Monoverticillata* section, *P. waksmani*, *P. restrictum*, *P. decumbens*, *P. adametzi*, *P. frequentans*, *P. terlikowski*, *P. fellutanum*, *P. lividum* and in the *Asymmetrica-Divaricata* section, *P. jensenii*, *P. canescens*, *P. raciborski*, *P. pulvillorum* were the most active.

Almost all the examined species of *Penicillium* utilize hexadecane and the secondary aliphatic alcohol (37°C). Somewhat less readily utilized were liquid and hard paraffins, paraffin oils, aliphatic acids (C₁₇—C₂₀). Almost all species utilize cyclic hydrocarbons. Aliphatic acids (C₅—C₉) and the primary aliphatic alcohol (38°C) were not taken up at all.

The strains of genera *Botrytis*, *Gliocladium*, *Pestalotia* did not grow in any of the tested hydrocarbons.

We can sum up the above reported results in the following conclusion.

1. Fungi from different systematic groups: *Phycomycetes*, *Ascomycetes*, *Fungi imperfecti* can actively use many oil hydrocarbons as carbon source.

2. The ability of hydrocarbon utilization is characteristic for many genera and species of these systematic groups, but the highest activity as regards selective ability of taking up different oil fractions is characteristic for definite strains.

3. The morphological properties of fungi from almost all genera of *Fungi imperfecti* are somewhat different from those cultured on media with carbohydrates.

*Wykorzystywanie węglowodorów przez grzyby mikroskopowe
w zależności od ich stanowiska systematycznego*

Streszczenie

Zbadano pod kątem wykorzystania węglowodorów ponad 600 szczepów grzybów z różnych klas. Okazało się, że zdolność tę wykazują liczne gatunki z rzędu *Mucorales* i z grupy *Fungi imperfecti*. Część grzybów jednak może wykorzystywać aktywnie i selektywnie tylko niektóre frakcje, inne zaś w ogóle nie wykazują takiej zdolności w stosunku do związków użytych do badań.