Coal Biodegradation by Basidiomycetes for Production of Biofertilizers and Soil Conditioners

Olga Klein[1], Elena Stepanova[1], Natalia Kulikova[1,2], Olga Koroleva[1]

[1]A.N. Bach Institute of Biochemistry Russian Academy of Sciences, Leninskii 33, 119071,Moscow, Russia, klein_olga@list.ru

[2]Department of Soil Science, Lomonosov Moscow State University, Leninskie Gory, 119992, Moscow, Russia

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1. INTRODUCTION

Coal is a traditional energy source for many countries and its use will not be reduced in the nearest future in spite of environmental damage by this energy source. Therefore great attention is paid for development of technological approaches to convert hard coal or lignite to a clean, cost effective energy source or to product value added products (1). The technological approaches focusing on conversion of coal slime and sludge as wastes of coal industry is also of great importance For Russian Federation.

The most perspective for conversion of coal slime considered to be biotechnological approaches based on microbial and/or enzymatic treatment (1, 2). These approaches are environmentally safe, cost efficient (carrying out at moderate pressure and temperature) and resulted in production of bioactive compounds.

The aim of the present study was to develop an approach for conversion of coal slime by Basidiomycetes and characterize the products formed during biotransformation.

2. MATERIALS AND METHODS

Pure culture of Basidiomycete *Coriolus hirsutus* 075 (Wulf. Ex. Fr) Quel. was used in this study. The samples of brown coal from Sonzevskoy deposit (Sakhalin, Russia) were used. For the experiments, the coal sample was air-dried, grinded and sieved through 1 mm sieve.

The strain was surface-cultivated in 250-ml flasks containing 50 ml of full or poor (without a favored carbon source glucose) nutrition medium, porcelain beads and inoculum. Full nutrition medium was prepared using following compounds (g/l): glucose (10.0), peptone (3.0), KH_2PO_4 (0.6), $ZnSO_4 \cdot 2H_2O$ (0.001), K_2HPO_4 (0.4), $FeSO_4 \cdot 7H_2O$ (0.0005), $MnSO_4 \cdot 7H_2O$ (0.05), $MgSO_4 \cdot 7H_2O$ (0.5) at pH 6.0. Inoculum was prepared

according to (3). When required, 5 g of coal was added to the flask. Coal samples were sterilized by heating to 120°C for 1 h. Surface cultivation lasted for 30 days.

During the cultivation biomass of *Coriolus hirsutus* mycelium was monitored. At the end of cultivation coal was separated from the nutrition media by filtration, dried at 50°C, and weighted.

To estimate biological activity of the residual nutrition medium after fungi cultivation, bioassay experiments were conducted using seedlings of wheat *Triticum aestivum* L. as target object. Seeds were germinated in the residual nutrition medium for 72 h at 24°C. Then length of shoots and roots were measured and used as response.

3. RESULTS AND DISCUSSION

Coal biotransformation can be considered as complex process including enzymatic, non-enzymatic and enzyme mediated stages. The strain *Coriolus hirsutus* grew rather well both on poor and rich nutrition media under static conditions. The introduction of coal in the media resulted in significant increasing of fungal biomass. The most profound effect has been observed during the growth of fungus on rich medium with coal sample: the amount of fungal biomass has increased in 60 folds compared with blank (rich media without coal). During the growth on poor media containing coal, a 14,5 fold increase in fungal biomass has been determined. Analysis of the obtained data allowed concluding the ability of basidiomycetes namely *C. hirsutus* to utilize coal as nutrient source.

The cultivation of *C. hirsutus* on both media with introduced coal resulted in decrease in coal weight. Obtained results are presented in Table 1. The most drastic decrease (up to 83% of initial weight of coal) was observed when poor medium was used. The latter indicated for the coal utilization Basidiomycetes as a carbon source confirming our assumption.

Table 1. Losses of coal during liquid surface cultivation of *Coriolus hirsutus* 075 (Wulf. Ex. Fr) Quel. under full and poor nutrition media conditions.

Variant	Weight of coal, % of initial
Blank, poor medium	100
Poor medium	83
Blank, full medium	100
Full medium	90

The comparative study of biological activities of residual cultural liquids after fungus cultivation has been carried out. The data are presented in Fig. 1. Obtain results

demonstrated that among the variants studied, the full nutrition medium after fungi cultivation in the presence of coal possessed pronounced stimulating effect in relation to both wheat shoots and roots growth. That finding indicated that basidiomycetes *Coriolus hirsutus* 075 produced some bio-solubilized compounds from coal that possessed physiological activity towards seedlings. Therefore, it can be concluded that residuary full nutrition media after basidiomycetes *Coriolus hirsutus* cultivation in the presence of coal could be recommended for further study for its biological activity.

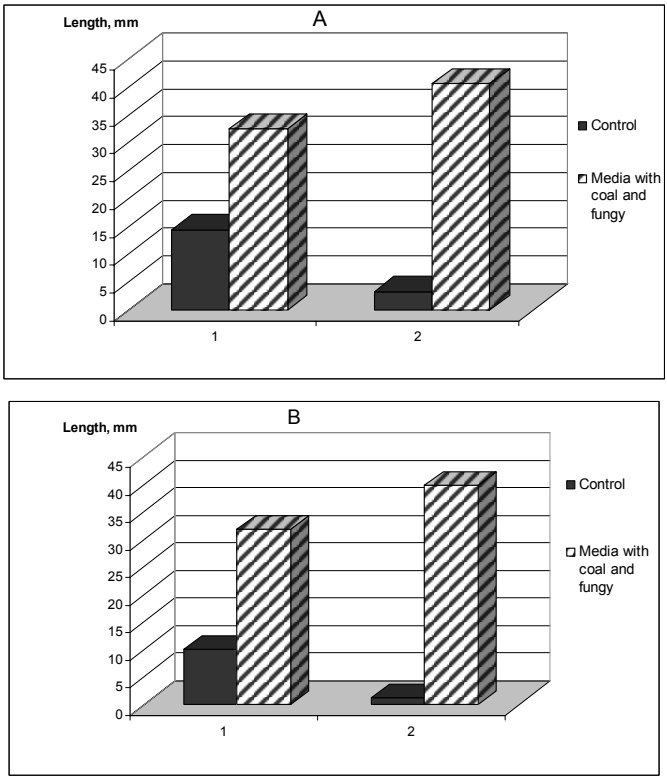

Figure 1. Influence of residuary nutrition media (A - poor media and B – rich media) on growth of shoots (1) and roots (2) of wheat Triticum aestivum L.

Analyzing the data it can be seen that limitation of carbon source (poor media) induced coal biotransformation with production of compounds utilized by fungi for biomass production. However growth on rich media resulted in enhance production of bioactive compounds. The further study will be focused on characterization of these compounds and their biological activity.

4. CONCLUSIONS

The performed experiments on *Corioulus hirsutus* cultivation demonstrated the ability of basidiomycetes to utilize coal as nutrient source under the surface cultivation. Among the variants studied (liquid surface cultivation conditions on full and poor media) the most pronounced decrease of coal weight was registered for the variant of liquid surface cultivation using poor nutrition medium. The most significant increase in fungal biomass production was observed during cultivation using rich nutrition medium.

Our findings indicated that basidiomycetes *Coriolus hirsutus* 075 produced some bio-solubilized compounds from coal that possessed physiological activity towards wheat seedlings. Residuary poor nutrition media after basidiomycetes *Coriolus hirsutus* 075 cultivation was seemingly not so effective as compared to full medium. Residuary full medium after basidiomycetes *Coriolus hirsutus* 075 cultivation possessed the greatest stimulating activity in terms of growth of both shoots and roots. This by-product of coal bio-solubilization could be therefore recommended for further study for its biological activity.

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