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MINERAL COMPOSITION OF THE SELECTED FRACTIONS FROM THE RAW AND BIODESULPHURIZED BITUMINOUS COALS

INTRODUCTION

One of the methods of coal desulphurisation is the method of microbial desulphurisation. The process concerns bacterial leaching of coal pyrite, and consequently pyrite sulphur (Dugan, 1986), and biodesulphurization follows the oxidation reaction of sulphide minerals:

$$MeS + 2O_2 \xrightarrow{\text{micro-organisms}} MeSO_4$$

In the case of microbial leaching of pyrite present in coal the process follows the equations (Fecko et al., 1991; Lungren, Silver, 1980):

$$2FeS_2 + 7O_2 + H_2O \xrightarrow{\text{micro-organisms}} 2FeSO_4 + 2H_2SO_4$$
$$2FeSO_4 + 1/2O_2 + 2H_2SO_4 \xrightarrow{\text{micro-organisms}} Fe_2(SO_4)_3 + H_2O$$
$$2FeS_2 + Fe_2(SO_4)_3 \xrightarrow{\text{micro-organisms}} 3FeSO_4 + 2S$$
$$S + 1/2\ O_2 + H_2O \xrightarrow{\text{micro-organisms}} H_2SO_4$$

The most often applied are sulphur bacteria species: *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans* (Chandra et al., 1980).

The additional effect of microbial desulphurisation of coal is the decrease of trace element concentrations as a result of their microbial and chemical leaching occurring in the process (Moran et al., 2002). The content of the trace elements can be reduced up to 90% or even 100% of their original concentration (Lewińska-Preis et al. 1999, 2001). The result of microbial desulphurization is also alteration of coal organic matter. It can be biodegraded to the large stage (Fabiańska et al.1999, 2003).

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In the paper presented here we try to answer the question whether changes occurring in coal as a result of microbial desulphurisation are reflected in the mineral coal composition.

EXPERIMENTAL

Samples description

The 6kg sample of the fine coal from the “Janina” coal mine was the object of investigation. After the prior grounding and mixing it was divided into two parts. The first one was microbially desulphurized and the second one was left as a raw coal sample.

At the next stage both coals: raw and biodesulphurized were separated by mixtures of heavy liquids into nine density fractions, from which the following were chosen for analysis: fraction 4 (1.34-1.42 kg/m^3) and fraction 7 (1.80-2.30 kg/m^3). Raw coal density fractions (1) were coded as 1/4 and 1/7, and the same the biodesulphurized coal density fractions (2) as 2/4 and 2/7. The 1/4 density fractions was characterized by the highest content of organic matter (98%, with 92% of vitrinite macerals), while the 1/7 density fraction showed the high content of mineral substances (22%).

The whole preparation of the samples was performed by the PN-80/G-04502 norm.

Analytical methods

All analytical research concerned the petrographic and mineral composition of the raw and biodesulphurized coals and their selected density fractions. Additionally the mineral composition of extracted coals (macromolecular fraction) and cokes from density fractions of the raw and biodesulphurized coals were investigated.

Macromolecular fraction of the density fractions was prepared by their extraction in a ultrasonic bath with a mixture of dichloromethane and ethanol. Next the extracted samples were pyrolysed to receive cokes (final temperature of pyrolysis 525^{o}C).

Petrographic investigation, which included analysis of maceral composition and mineral matter content, was carried out on pellets prepared by the PN-92/G-04563 norm, and measurements of the vitrinite reflectance were performed on the same pellets by PN-92/G-4524.

Mineral composition was investigated with a X-ray diffractometer (Philips PW-3710).

RESULTS

Petrographic composition of the samples is shown in the table 1, and their mineral composition in the table 2.

In the analyzed samples, apart from the crystal phases shown above, gypsum, calcite and dolomite are present in trace amounts.

The all samples contained also amorphous matter. In some samples it is composed of carbonized organic substances, while in the other it is amorphous phase of unknown composition formed during samples roasting. Its content assessment, as well as of the other components, may show relatively large measurement error since X-ray diffractometry is the method of investigation of ordered crystalline materials. As a result, the data shown in the table 2 have only general estimation value.

Table 1

Petrographic composition of the investigated samples of the raw (1) and biodesulphurized (2) coals

Sample	Density fraction content in the coal (%)	Maceral groups (%)			Mineral substance (%)	Ro (%)
		vitrinite	liptinite	inertinite		
1 1/4 1/7	- 28,85 22,30	52 92 46	5 3 1	13 4 31	30 1 22	0,54
2 2/4 2/7	- 70,40 1,33	72 80 53	4 4 3	19 14 21	5 2 23	0,55

DISCUSSION ON ANALYTICAL RESULTS

Changes found in mineral composition of the investigated samples being the result of microbial desulphurization concerns mainly quartz, argillaceous minerals and pyrite presence.

In the biodesulphurized coal the quartz content decreases in 56%, while argillaceous minerals in 40% and pyrite in 20%. Similar trends can be found in the 2/4 and 2/7 density fractions as well as in macromolecular coal fraction and cokes from these density fractions (tab.2). In all these samples the decrease of quartz in mineral composition occurs in the range from 40 to 60%, and argillaceous minerals from 30-86%. Pyrite content in the 2/4 density fraction is the same as in the 1/4 fraction, while in the 2/7 fraction it increases.

The decrease of mineral concentration in the biodesulphurized coal and its density fractions was also found in petrographic research. The raw coal contains 70% of organic matter and 30% of mineral substance while desulphurized coal consist of 95% of organic matter and only 5% of minerals.

In the petrographic composition of the 1/4 density fraction organic matter dominates, and mineral substance is only 1% of the total fraction composition. The 1/7 density fraction contained high amount of mineral substances, which comprised 22% of the total density fraction composition. Considering the content of this fraction in the total coal it may be assumed that this density fraction is the mineral-bearing fraction.

Table 2

Mineral composition of the investigated samples of the raw (1) and biodesulphurized (2) coals.

Sample		Mineral composition (%)						
		Amorphous carbonised substance	Argillaceous minerals	Quartz	Feldspar	Anortite	Pyrite Marcasite	Hematite
Coal	1	30	25 (kaolinite, illite)	30	5	-	10	-
	2	60	15 (kaolinite)	17	-	-	8	-
Fraction 4	1	60	10 (kaolinite with chlorite, illite)	25	-	-	5	-
	2	75	10 (kaolinite)	10	-	-	5	-
Macro-molecular fraction	1	35	15 (illite> kaolinite)	20	-	25	-	5
	2	32	2 (illite)	10	-	45	-	10
Coke	1	27	10 (illite)	25	-	30	-	8
	2	10	7 (illite)	15	3	50	-	15
Fraction 7	1	21	32 (kaolinite, illite)	40	trace	-	7	-
	2	20	22 (kaolinite, illite)	18	-	--	40	-
Macro-molecular fraction	1	15	12 (chlorite)	50	5	10	-	8
	2	17	6 (illite)	30	-	5	-	40
Coke	1	10	15 (illite, kaolinite)	50	5	10	-	10
	2	11	6 (illite)	20	-	8	-	55

- the given mineral was not found

In the coal after the microbial desulphurization process the 2/4 density fraction also predominantly is composed of organic matter. Moreover, this fraction became a mineral-bearing fraction (tab. 1). It shows that the mineral substance of this fraction was not changed in the large stage in microbial desulphurization as it was in the case of the mineral substance present in the 2/7 density fraction.

The 2/7 density fraction also shows high stage of organic matter biodegradation (Fabiańska et al., 1999, 2003).

High decrease of mineral substance and biodegradation of organic matter cause the decrease of the total weight of the fraction, thus the increase of the mineral concentration, which content was not reduced . This fact can explain increasing pyrite content in the mineral composition of the fraction.

Differences discovered in the mineral composition of the raw and biodesulphurized coal are caused by the changes occurring in coal mineral substance as a result of microbial desulphurization. This process results in the decrease of concentration of mineral substance in the coal after its desulphurization up to 76%. (Lewińska-Preis et al., 1999).

CONCLUSIONS

- Process of the microbial desulphurization caused changes in the mineral composition of the Janina mine coal.

- Changes in the mineral composition of the biodesulphurized coal concern mainly quartz, argillaceous minerals and pyrite presence

- In the biodesulphurized coal from the Janina coal mine quartz content decreased in 56%, argillaceous minerals in 40% and pyrite in 20%.

- In the 1/4 density fraction (1.34-1.42 kg/m^3) of the raw coal and the 1/7 density fraction (1.80-2.30 kg/m^3) as well as in their macromolecular fraction and cokes the content of quartz and argillaceous minerals decreased.

- In macromolecular fraction from the 1/4 density fraction (1.34-1.42 kg/m^3) the highest decrease of argillaceous minerals content occurred.

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