TECHNICAL REPORT

September 1, 1991 through November 30, 1991

Project Title: **SULFUR REMOVAL FROM HIGH-SULFUR ILLINOIS COAL BY
LOW-TEMPERATURE PERCHLOROETHYLENE (PCE) EXTRACTION**
DE-FG22-91PC91334

Principal Investigator: M.-I. M. Chou, Illinois State Geological Survey (ISGS)
Funded Coinvestigator: D.H. Buchanan, Professor, Eastern Illinois University (EIU)
ISGS Coinvestigators: John Lytle, R.R. Ruch, C.W. Kruse, C. Chaven, K.C. Hackley, R.E. Hughes, R. D. Harvey, J.K. Frost
Other Coinvestigators: J.W. Stucki, Professor, University of Illinois, Urbana-Champaign, P. Huffman and F.E. Huggins, Professors, University of Kentucky, Lexington (UK)
Project Monitor: Dr. Dan Banerjee, CRSC

ABSTRACT

A pre-combustion coal desulfurization process at 120°C using perchloroethylene (PCE) to remove up to 70% of the organic sulfur has been developed by the Midwest Ore Processing Co. (MWOPC). However, this process has not yet proven to be as successful with Illinois coals as it has for Ohio and Indiana coals. The organic sulfur removal has been achieved only with highly oxidized Illinois coals containing high sulfatic sulfur. A logical explanation for this observation is vital to successful process optimization for the use of Illinois coals. In addition, the high levels of organic sulfur removals observed by the MWOPC may be due to certain errors involved in the ASTM data interpretation; this needs verification. For example, elemental sulfur extracted by the PCE may be derived from pyrite oxidation during coal pre-oxidation, but it may be interpreted as organic sulfur removed by the PCE using ASTM analysis.

The goals of this research are: (1) to independently confirm and possibly to improve the organic sulfur removal from Illinois coals with the PCE desulfurization process reported by the MWOPC, (2) to verify the forms-of-sulfur determination using the ASTM method for the PCE process evaluation, and (3) to determine the suitability of Illinois coals for use in the PCE desulfurization process. This project involves the Illinois State Geological Survey (ISGS), Eastern Illinois University (EIU), the University of Illinois-Urbana/Champaign (UI-UC), and the University of Kentucky, Lexington (UK). This is the first year of a two-year project.

In this reporting period, a total of 19 PCE desulfurization tests were conducted on a fresh IBC-104 coal and many oxidized forms of this coal. Elemental sulfur from the PCE extractions was analyzed. The results show a relationship between the amount of elemental sulfur from the extraction and the level of coal pre-oxidation. Elemental sulfur extraction was enhanced by coal oxidation prior to the PCE extraction. The observed elemental sulfur from a highly oxidized coal sample was 25 to 75 times greater than those of mild oxidized coal samples. Analyses of the residues produced from these desulfurization tests are in progress.

MASTER

This project is funded by the U. S. Department of Energy (PETC) and by the Illinois Department of Energy and Natural Resources as part of their cost-shared program.

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EXECUTIVE SUMMARY

The development of economical and practical processes to remove both organic and pyritic sulfur under mild reaction conditions would be highly beneficial to the Illinois coal industry. A pre-combustion desulfurization process operating at 120°C using perchloroethylene (PCE) to remove up to 70% of the organic sulfur in the elemental sulfur form has been developed by the Midwest Ore Processing Co. (MWOPC). The importance of oxidation and drying conditions as well as temperature control is stressed by the MWOPC. The process is effective in extracting organic sulfur and in float-sink separating pyrite fines from coal; the process can be operated at low temperatures with minimal loss of solvent (Leehe et al., 1988 and 1989; Lee et al., 1990) and was found to effectively remove organic sulfur from high-sulfur coals obtained from Ohio and Indiana. However, it has not yet proven to be as successful with Illinois coals (Lee et al., 1990; Buchanan et al., 1990).

Over the past few years, the ISGS and Eastern Illinois University (EIU) have jointly developed analytical methods to measure forms of sulfur in the PCE extracts from PCE extraction of high-sulfur Illinois coals. Some elemental sulfur and limited amounts of organic sulfur have been removed from oxidized Illinois coals during these studies; however, these sulfur removals (<32%) were much lower than those reported by the MWOPC (>43%). Several hypotheses may explain these differences, but to date, no experimental supports have been reported. MWOPC assumed that organic sulfur removal was due mainly to the removal of aliphatic sulfur, and that the organic sulfur in the Illinois coals may contain less aliphatic sulfur than the other coals tested. Others have postulated that certain errors in interpreting ASTM data may result in higher organic sulfur removal reported by the MWOPC.

For example, one hypothesis underlying the ASTM analysis is that pre-oxidation of coal may convert pyrite into PCE-extractable sulfur, and that this oxidation leaves behind pyrite-derived iron. This iron may not be extractable by HCl but may be extractable by HNO₃. If so, this iron would be counted as pyritic sulfur during the ASTM analysis. Since the ASTM "pyritic sulfur" appears to remain constant and the ASTM organic sulfur is obtained by the difference between total sulfur and the sum of pyritic sulfur and sulfatic sulfur, this calculation would lead to an error in interpreting the ASTM results, making it appear that the removal of sulfur by PCE extraction is organic in nature.

The goals of this research are: (1) to independently confirm and possibly to improve the organic sulfur removal from Illinois coals with the PCE desulfurization process developed by the MWOPC, (2) to verify the forms-of-sulfur determination using ASTM method for the PCE desulfurization process evaluation, and (3) to determine the suitability of Illinois coals for use in the PCE desulfurization process. This is a joint effort by the ISGS, EIU, UI-UC, and UK. A total of 8 tasks, tasks 1 to 5 will be completed in the first year, and tasks 6 to 8 will be carried out in the second year. During this reporting period, tasks 1 and 4 are partially completed. The activities of these two tasks are summarized below.

The purpose of task 1 is to perform PCE desulfurization on the selected Illinois coal under proper conditions described by the MWOPC procedures. Thus, the derived process intermediate products before and after PCE extraction can be used to evaluate the fate of sulfur transformation in the PCE process and also to verify the ASTM analyses. A total of three PCE desulfurization tests were conducted on fresh IBC-104 coal from the Illinois Basin Coal Sample Program. The process condition included two different drying techniques prior to PCE extraction. The results indicate that drying before any other treatment for PCE extractions improves the elemental sulfur extraction. On a preliminary ASTM analysis, desulfurization data obtained from this fresh IBC-104 coal is comparable to that obtained by the MWOPC process. In the next quarter, the process will be refined, and the PCE extractions will be repeated in a larger scale (50 g size) on one short term oxidized IBC-104 coal, the long term oxidized IBC-104 coal, and the Ohio 5/6 coal. The process feed, and product from these scale up operations will be distributed to co-investigators for the independent analysis. Also, the forms of sulfur determinations and chlorine determinations by the ASTM method for these samples will be examined.

The purpose of task 4 is to determine the effect that various oxidation conditions have on PCE desulfurization. In this reporting period, a total of 16 PCE desulfurization tests were conducted. An IBC-104 coal with -60 mesh particle size was subjected to oxidation under various conditions including dry-oxidation, ambient-oxidation, wet-oxidation, steam-air oxidation, and other forms of oxidation. The results of the oxidization study indicate that the level of elemental sulfur removal is greatly enhanced by a long-term (>5 years) air oxidation of the same IBC-104 coal. The extractable elemental sulfur obtained from this sample is 25 to 75 times greater than those from the short term oxidized IBC-104 coal samples.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

GOALS AND OBJECTIVES

The goals of this research are: (1) to independently confirm and possibly improve the organic sulfur removal from Illinois coals with the PCE process, (2) to verify the ASTM forms-of-sulfur determination, and (3) to evaluate the suitability of Illinois coals for use in the PCE desulfurization process developed by the MWOPC. Successful removal of organic sulfur during PCE extraction or by other methods developed to improve PCE extraction of Illinois coals can greatly improve the marketability of high-sulfur Illinois coal.

Specific objectives are:

- A. To conduct the PCE desulfurization of two coals under the proper process conditions. One coal, IBC-104, would be from the Illinois Basin Coal Sample Program, and the other, Ohio 5/6 coal, from the Horizon Coal Company.
- B. To carry out an extensive material balance study on the feed materials and products from the two coals tested in the PCE desulfurization process.
- C. To conduct ASTM-independent analyses with forms-of-sulfur determinations and compare the results.
- D. To investigate coal oxidation chemistry and its effect on the mechanisms of sulfur removal by the PCE desulfurization process.
- E. To examine the role that pyrite in coal plays during the PCE desulfurization process and its influence, if any, on process optimization.
- F. To evaluate and possibly improve the effectiveness of the PCE desulfurization process for Illinois coals.

INTRODUCTION AND BACKGROUND

MWOPC has reported a method of removing organic sulfur from high-sulfur coal using perchloroethylene (PCE) leaching at 120°C (Starbuck, 1980; Leehe et al., 1988, 1989). The process was partially supported by the Electric Power Research Institute (EPRI) and has been operated in a pilot plant of 1 ton/day capacity by MWOPC at Plainville, IN. In addition, a mini-pilot plant of 5 lb/hr capacity is being operated at The University of Akron (UA; Lee et al., 1990). Results from the mini-pilot plant indicated that the PCE process effectively extracts organic sulfur, and is equally effective in separating pyrite fines from coal. The process can be operated at low temperatures with a minimum loss of solvent (Lee et al., 1990). The importance of oxidation and drying conditions as well as temperature control is stressed by the MWOPC. Efficiency of organic sulfur removal is affected by the initial moisture content in coal (Fullerton et al., 1990). A "catalyst" involved in the process, which renders organic sulfur more accessible to the PCE extraction, has been suggested (Personal communication to PI, G. A. Atwood, MWOPC, Feb. 1991). This process has been found to effectively

remove organic sulfur from high-sulfur coals obtained from Ohio and Indiana. However, it has not yet proven to be as successful with Illinois coals (Lee et al., 1990).

A cooperative study (Buchanan et al., 1990) between Eastern Illinois University (Buchanan) and ISGS (Chaven and Hackley) was initiated in 1988. The procedure developed was different from that of MWOPC in that (-60 mesh) coals were used without pre-oxidation prior to PCE extraction. Also, these experiments were mainly conducted in a soxhlet extraction apparatus using a small sample size (1 to 24 g) as compared to the other experiments in which 50 g or more were used. The authors concluded that the source of the elemental sulfur extracted from coal by PCE under these conditions was pyrite and that little organic-sulfur was removed (Buchanan et al., 1990). These results differ from those of MWOPC's study where as much as 43% removal of organic sulfur from an Illinois coal has been reported (see Literature review, Table 3).

The differences between the results of the MWOPC and EIU/ISGS may have been due to the use of different process conditions such as pre-oxidation, extraction apparatus, and sample size. For example, soxhlet extraction rather than batch extraction could decrease the activity of the catalyst that assists organic sulfur removal during PCE extraction. Extraction of smaller sample sizes could decrease the required temperature control. However, others have postulated that some possible errors in the ASTM analyses of sulfur may explain the discrepancies in the results. For example, during pre-oxidation, pyrite may convert into PCE extractable elemental sulfur and leaves the pyrite-derived iron behind. This iron may remain insoluble in HCl but soluble in HNO₃ during ASTM analysis. Because the elemental sulfur has been removed by PCE, the total sulfur content decreases, and therefore the calculated amount of organic sulfur also decreases. This calculation would lead to an error in interpretation of the ASTM results, making it appear that the removal of sulfur by PCE extraction is organic in nature (Buchanan, 1991). As yet, these postulates have not been confirmed.

EXPERIMENTAL

Task 1: Processing of Illinois coals and a mass balance study (ISGS/EIU)

The purpose of this task is to perform PCE desulfurization on the selected Illinois coal under proper conditions described by the MWOPC procedures. Thus, the derived process intermediate products before and after PCE extraction can be used to evaluate the fate of sulfur transformation in the PCE process and also to verify the ASTM analyses.

In this quarter, coal samples were prepared and a total of 19 PCE desulfurization tests were conducted. Procedures for sample selection, preparation, and PCE extraction are described as follows:

Coal Sample Selection

Two coals, one from the Illinois Basin Coal Sample Program (IBC-104) and the other from the Horizon Coal Company (Ohio 5/6 coal) were selected for this project. Coal sample selection is based on the availability of the samples and of the reported desulfurization data by the MWOPC and the UA. Thus, this allows a base line of comparison to be made between the data generated in this investigation and those reported.

Table 1. ASTM forms of sulfur in an Illinois No. 6 coal and an Ohio 5/6 coal before and after PCE extraction (Univeristy of Akron, Lee et al. 1991).

<u>SAMPLE</u>	<u>SO₄</u>	<u>PYR</u>	<u>ORG</u>	<u>TOT</u>
Feed (IBC-104) IL No. 6 F	0.01	2.54	1.55	4.10
PCE residue	0.01	2.52	1.36	3.89 ^{-5%}
Feed Ohio 5/6 W	0.22	1.40	1.58	3.20
PCE residue	0.23	1.40	0.71	2.34 ^{-27%}

F = fresh coal; W = weathered at room temperature, the higher level of sulfatic sulfur content indicative of the higher level of oxidation of the sample; ^{-5%}, total sulfur reduction from the feed coal.

Coal Sample Preparation

An 18 lb bag of fresh IBC-104 (F-IBC-104) was obtained from Illinois Basin Coal Sample Program (Dr. Carl Kruse, P.I.) in 28 mesh size and was further ground to -60 mesh using a Holmes Mill. Four of these 32 splits were further split into 64 bags (approximately 24g in each bag) for use in this quarter. The remaining 28 splits were stored under the nitrogen atmosphere maintained by the Illinois Basin Coal Sample Program.

A 5 lb. (2250g) can of Ohio 5/6 coal was received from Dr. Conrad Kulik of EPRI through Dr. D. Buchanan. This coal sample was supplied in -60 mesh and was split 5 times to get 32 bags with approximately 70g/bag. Of these 32 bags, 30 were preserved under nitrogen atmosphere maintained by the Illinois Basin Coal Sample Program. The remaining 2 bags were split 2 times into 8 bags with approx. 24 g in each bag for preliminary coal analysis.

In addition to F-IBC-104, a long-term (>5 years) oxidized version of this coal (O-IBC-104), and some short-term oxidized forms of IBC-104 coal (see table 2) were used in the PCE extraction tests.

PCE Extraction

All the PCE extractions were conducted at 121°C for a duration of thirty minutes, and the residue produced from PCE extraction was isolated by hot filtration. The process variables for PCE extraction included the method of drying, and the method of oxidation during or before the PCE extraction. The solvent to coal ratio used ranged from 5 to 14.

The controlled coal sample (F-IBC-104) was extracted by PCE immediately after either vacuum or azeotropic drying.

Vacuum drying refers to Abderhalden, 0.05 Torr, overnight at room temperature prior to oxidation (if any) and PCE extraction. (Feed coal moisture was found to be 9.3% by this method which is consistent with the result obtained from the ASTM method.)

Azeotrope drying refers to no vacuum drying prior to oxidation (if any) and PCE extraction. The sample is added to well-stirred PCE at 70° in an open flask, heating the mixture until all of the water boils out and the temperature in the flask is raised to 121° at which time a condenser is put in place and refluxing maintained for 30 minutes to complete the extraction.

The pre-oxidations included air oxidation in the presence of PCE, air oxidation in the presence of water and ferric ion, air oxidation at room temperature, and other forms of oxidation. The detailed experimental conditions are described under Task 4.

Task 2: Independent analysis for forms of sulfur determination (ISGS, UI-UC, & UK).

Task 2.1: A wet-chemical analysis (ISGS).

No work was done for this subtask during the reporting period.

Four non-destructive spectroscopic techniques (Tasks 2.2 - 2.5) will be used for determining the fate of organic sulfur, pyritic sulfur, and sulfur-containing iron salts in each step of the PCE desulfurization process.

Task 2.2: Sulfur K-edge X-ray absorption fine structures (XAFS) spectroscopy (University of Kentucky).

Task 2.3: X-Ray Diffraction (XRD).

Task 2.4: Mössbauer spectroscopy (UI-UC).

Task 2.5: Scanning Electron Microscopy and Energy Dispersive x-ray (SEM-EDX).

No work was done for these subtasks during the reporting period.

Task 3: Evaluating the Effectiveness of Using the PCE Desulfurization Process on the Selected Illinois Coal, and Verifying the ASTM Forms of Sulfur Analyses (ISGS, EIU, UI-UC, and UK).

The data obtained from Tasks 1 and 2 on sulfur removal for the coals processed will be examined, evaluated, and interpreted. Data from ASTM analysis (Task 1.2) and LAH analysis (Task 2.1) will be compared on the basis of sulfur reduction using PCE desulfurization process as a whole and as in each step of the process. Data from spectroscopic analyses (Tasks 2.2 - 2.5) will be examined with respect

to the transformation or removal of pyritic sulfur, aliphatic sulfur, and aromatic sulfur in each step of the PCE desulfurization process. Interpreting these data will allow us to explore the true identity of sulfur removal by PCE extraction and that of ASTM forms-of-sulfur analysis.

Task 4. Conducting PCE desulfurization under various process conditions (EIU/ISGS).

The purpose of this task is to determine the effect that various oxidation conditions have on PCE desulfurization.

In this reporting period, an IBC-104 coal with -60 mesh particle size was subjected to oxidation under various conditions including dry-oxidation, ambient-oxidation, wet-oxidation, steam-air oxidation, and other forms of oxidation. The oxidized and unoxidized samples were then treated with PCE. PCE extracts were analyzed for elemental sulfur content. The oxidation conditions listed in Table 2 are detailed as follows:

Air oxidation in the presence of PCE (Air in PCE) was conducted by bubbling filtered air through a coal/PCE slurry at 90°C with the oxidation duration increased from 1 hour, to 2 hours, to 20 hours respectively. In one study, the oxidation process was conducted under pure oxygen instead of air for two hours.

Air oxidation in the presence of water and ferric ion (H_2O/Fe^{3+}) was conducted by bubbling filtered air through a coal/PCE slurry with the presence of water and ferric ion at 90°C. The oxidation duration varied from 1 hour to 2 hours respectively.

Room air oxidation (Rm air) was conducted by spreading the coal sample into a thin layer, and leaving the container open to the laboratory air for two weeks.

Another form of oxidation (Mst Oven) occurred in an air tight oven with a crystallization dish full of hot water. This provided a moisture-rich environment for the coal sample to be oxidized at 80°C for two hours.

Oxidation with moistened air in PCE (MAir in PCE) followed the same procedure as air in PCE. The only difference was that the air was moisturized by bubbling through hot water prior to the introduction to the PCE/coal slurry.

Oxidation under heated air (PvsAir) involved blowing hot air up through a miniature fluidized bed of coal. The glass tube had a fritted disk sealed in the middle and it was kept hot by the heating tape. Oxidation reaction was maintained at 80°C for two hours.

In long term air oxidation (Rm Air >5y), the coal sample was stored in a non-air tight container under laboratory environment for greater than five years.

Task 5. Evaluating the parameters studied and their effect on process optimization (ISGS, EIU, UI-UC, and UK).

The results of the ASTM forms-of-sulfur analyses in oxidized coals will be

compared with those in the non-oxidized coal. The possible effects that various pre-oxidation conditions have on sulfur removal during PCE extraction will be determined. Data from the other variables studied will also be evaluated with respect to their effects on the process efficiency for the two coals tested. Data obtained from the optimum conditions (if any) will be compared with those reported by the MWOPC and UA.

Task 6. Verifying the possible effect of PCE treatment on coal-derived FeS_2 , FeS , FeSO_4 , FeS_2 , and coal analyses (ISGS/EIU).

This task will be carried out in the second year for a base line study to verify the possible effect of PCE extraction on the ASTM forms-of-sulfur analysis. Separate experiments using control samples will be conducted. An IBC-104 coal, pyrite, and pyrite-derived iron phases (e.g., FeSO_4 , FeS , etc.), and/or coals with added iron salts will be subjected to PCE extraction. The PCE extracts will be analyzed for elemental sulfur. Hot HCl and HNO_3 acid digestions of the residues will be analyzed for sulfur and total Fe.

Task 7. Using radioactive pyrite to monitor sulfur behavior during PCE desulfurization (ISGS/EIU).

This task will be carried out in the second year. The role that pyrite may play and the fate of iron and sulfur associated with pyrite during PCE desulfurization will be examined using a radioactive pyrite doping technique.

Task 8: Application of an acceptable PCE desulfurization process to Illinois coals (ISGS).

This task will be carried out in the second year. If it is found (Task 5) that significant amounts of organic sulfur are being removed from Illinois coal by the PCE desulfurization process, the optimized operation conditions of the process will be applied, and the applicability of the process to the most economically important Illinois coals will be examined. In addition, a complete PCE desulfurization process including the float-sink separation step will be performed.

RESULTS AND DISCUSSION

In the first quarter, a total of 19 PCE desulfurization tests were conducted. The results from product analysis of fresh IBC-104 coal (F-IBC-104) and other oxidized forms of this coal are partially completed. The process conditions and the sulfur analysis data are listed in Table 2. Two drying techniques plus various oxidation techniques prior to the PCE extraction were examined for their effect on the elemental sulfur extraction and the total sulfur reduction.

Table 2. Process conditions and sulfur analysis data for PCE desulfurizations.

Lab Run # /Sample #	Coal Wt. (g)	PCE (mL)	Drying Method	Oxidation Method	Wt % Recover	S * wt% Dry	Residue TS wt% Dry
F-IBC-104 C-31860							4.23
S4001 C-31915	12.63	100	Vacuum	None	93.6	0.00- 00*	4.05
S4002 C-31916	10.63	100	Vacuum	None	95.6	0.0000	4.05
S4101 C-31917	9.65	100	Azeotrope	None	84.9	0.0000	3.98-6*
S4102 C-31918	10.08	100	Azeotrope	Air in PCE 1 hr	85.8	0.0009	4.18
S4103 C-31919	11.36	75	Azeotrope	Air in PCE 2 hr	90.2	0.0019	4.04
S4201 C-31920	9.63	75	Vacuum	Air in PCE 2 hr	99.0	0.0027	4.08
S4104 C-31927	9.94	100	Azeotrope	Rm Air 2 wk	96.1	0.0008	4.05
S4105 C-31928	15.70	100	Azeotrope	Mst Oven 80 °C 2 hr	91.4	0.0017	4.11
S4106 C-31929	10.85	100	Azeotrope	H ₂ O/Fe ³⁺ 2hr	86.92	0.0011	4.06
S4202 C-31930	9.88	100	Vacuum	Rm Air 2 wk	96.8	0.0010	3.76-11*
S4203 C-31931	11.05	100	Vacuum	MAir in PCE 2 hr	99.2	0.0013	4.09
S4204 C-31932	9.51	100	Vacuum	H ₂ O/Fe ³⁺ 2hr	89.03	0.0011	4.02
S4107 C-31952	7.36	100	Azeotrope	H ₂ O/Fe ³⁺ 1hr	89.10	0.0023	4.29
S4207 C-31953	9.25	100	Vacuum	Rvs Air 80 °C 2 hr	97.54	0.0017	4.19

S4206 C-31954	9.25	100	Vacuum	O ₂ 2 hr 90 °C	96.82	0.0022	4.19
S4205 C-31955	7.94	100	Vacuum	Air 20 hr 90 °C	100.12	0.0024	4.11
0-IBC-104 C-31956							4.08
PCE-37 ^o C-31942	15.00	75	Azeotrope	Rm Air >5y	104.50	0.0680	3.37 ^{-17*}
S4311 C-31957	21.62	170	Azeotrope	Rm Air >5y	91.60	0.0704	3.74 ^{-8*}
S4321 C-31958	19.08	170	Vacuum	Rm Air >5y	98.11	0.0667	3.75 ^{-8*}

* Under detection limit.

^o This run was conducted at the ISGS, and all others were conducted at the EIU.

^{-6*} Total sulfur reduction for the run.

TS = Total Sulfur

S^{*} = Elemental Sulfur

Elemental Sulfur

The results of drying technique study indicates that drying prior to any other treatment improves elemental sulfur extraction, although there is no preference among the two drying methods studied. The results of the oxidation study indicate that the level of elemental sulfur removal is greatly enhanced by a long-term (>5 years) air oxidation of the same IBC-104 coal. The extractable elemental sulfur obtained from this sample is 25 to 75 times greater than those from the short term oxidized IBC-104 coal samples.

Total Sulfur

The data from total sulfur analysis on both fresh and short term oxidized coal samples are not yet concluded. All the possible errors will be taken into consideration before any specific interpretation is made. However, in general, these preliminary data indicate that the level of total sulfur reduction from non-oxidized coal F-IBC-104 has values ranging from 4% to 6% (see Table 2) which is comparable to the level of sulfur removal from a similar fresh Illinois #6 coal published by Lee et al. of the University of Akron (1991). In their published data (Table 1), a total sulfur removal of 5% was indicated. Also, our results clearly indicate that a long term air oxidation did improve the total sulfur reduction by PCE extraction. A total sulfur reduction observed for this long term air oxidized IBC-104 coal sample ranged from 8% to 17%.

In the next quarter, the process will be refined, and the PCE extractions will be repeated in a larger scale (50 g size) on one short term oxidized IBC-104 coal, the long term oxidized IBC-104 coal, and the Ohio 5/6 coal. The process feed and product from these scale up operations will be distributed to our co-investigators for the independent analysis. Also, the forms of sulfur determinations and chlorine determinations by the ASTM method for these samples will be examined.

SUMMARY AND CONCLUSION

Based on a preliminary ASTM analysis, desulfurization data obtained from fresh IBC-104 coal is comparable to that obtained by the University of Akron. Coal pre-oxidation before PCE extraction does enhance total sulfur reduction and elemental sulfur extraction.

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PROJECT MANAGEMENT REPORT

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Other Coinvestigators: J.W. Stucki, Professor, University of Illinois, Urbana-Champaign, P. Huffman and F.E. Huggins, Professors, University of Kentucky, Lexington (UK)

Project Monitor: Dr. Dan Banerjee, CRSC

COMMENTS

Contract for EIU has not yet been paid. This work is in progress but payments are made on a cost reimbursement basis after the end of the quarter. Thus, expenditures were less than expected for the first quarter.

This project is funded by the U. S. Department of Energy (PETC) and by the Illinois Department of Energy and Natural Resources as part of their cost-shared program.

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