EFFECT OF DIFFERENT PARTICLE SIZE ON DESULPHURIZATION OF COAL BY *Pseudomonas Species*

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ABSTRACT

Sulphur compounds present in coal impose severe limitations on its utilization since sulphur-containing gases emitted into the atmosphere upon direct combustion of coal cause serious environmental pollution problems. The effects particle size on the rate of sulphur removal were studied. Biodesulphurisation experiments were carried out with Sor Range coal Run of Mine at the optimum growth conditions of Pseudomonas sp. 8 samples of different composition based on particle size, slurry composition and bacterial concentration were tested throughout the experiment. The highest decrease in the total Sulphur was 23.93% of sample having composition 40 mesh, autoclave and incubation time of 120 hours respectively. Increased desulphurization rates have been observed with smaller particle sizes. 40 mesh size coal was found very effective during leaching process as compared to 20 mesh size coal. Furthermore, higher the incubation time higher the reduction rates of sulphur. The samples autoclave has a direct impact on the removal of sulphur. Ash was another factor which was reduced during the process. Highest decrease of 52.97% was observed for the sample having mesh particle size, autoclave and having incubation time of total 120 hours. Environmental conditions and major process variables affecting the process performance are identified and their possible effects are discussed.

Keywords: Coal, Desulphurization, *Pseudomonas sp*., Ash, Balochistan

1. INTRODUCTION

In recent years, with the rising price of crude oil, lack of oil and gas resources, global energy industry have been focused on accelerating the development of coal chemical industry [1].

Pakistan is one of the developing countries in the world with a very low energy consumption, high rate of population growth and in the early stages of managing to improve its living standards, by increasing its energy production through different sources for the development of industries. Despite of huge potential energy resources, the country remains energy deficient and has been heavily dependent on imports to meet their necessities [2].

Coal is recognized as an important energy source for centuries. Coal is considered as a source of alternative energy to oil because of the increasing demand due to global energy crisis. Economic growth and industrialization in developing countries led to the rapid growth of demand for energy. In other words, the increased demand for coal, which is cheap, can be used to generate electricity and process heat. In contrary, the International Energy Agency (IEA) predicted a significant thrive in their use in the coming years, increasing from 3.5 billion tons currently to over 5.3 billion tons per year [3]. When coal is burnt for different purposes, sulfur in coal reacts with oxygen resulting in formation of sulfur dioxide (SO_2), which has a hazardous role in pollution and acid rain [4].

Sulphur exists in three forms which are organic Sulphur, sulphate Sulphur, Pyritic Sulphur. Regardless of any type the removal of Sulphur compounds from coal is necessary to overcome the issue of environmental pollution caused by the emission of sulphurous compounds during combustion of coal [5].

Sor-Range coalfields are the northern half of the Sor-Range-Degari coalfields which are located 12 km south of Quetta city. These coal fields are extended up to 26 km and cover an area of about 50 sq.km. The coal found in Sor-Range is sub bituminous in quality. The sulfur and ash percentage in Sor-Range coal is 0.6 to 5.5 and 04.9 to 17.20 respectively. The coal reserves in

Sor-Rang are estimated at 50 million tones [5].

To the best of the authors' knowledge, only one strain of *Pseudomonas sp*., denoted CB1 strain and listed as ATCC No. 39381, obtained by chemical mutagenesis of a wild strain, is claimed to be so effective in removing some organosulfur compounds from coal therefore to encourage its testing with a view to commercial application [6].

In the present investigation, Sor Range coal (Pakistan) containing high percentage of sulphur was studied for the desulphurization process using *Pseudomonas sp*. collected from Punjab University Pakistan. Coal found in this region is mostly of sub bituminous type. Since it is important to achieve high sulphur reduction accompanied with good coal combustions parameters, attempts were made to reduce the sulphur as much as possible.

2. METHODOLOGY

2.1. Coal Sample

Coal sample used for the experiment was collected from Sor Range RoM located in Quetta, Pakistan. Coal obtained was crushed and grinded to obtain different particle size fraction and was sieved to obtain 20 (841 µm) and 40 (420 µm) mesh particle size for the desulphurization studies respectively.

2.1.1 Determination of Total Sulfur

For the determination of Total Sulphur present in Coal sample the ASTM D3177 established and classified methods is used. Total sulphur and ash present in coal was found out to be 4.8% and 11.1% respectively.

2.2 Microbial Culture

Pure cultures of *Pseudomonas Sp.* (patent strain ATCC No 39381) were obtained from the Department of Pathology at Punjab University Lahore. Cultures were cultivated and maintained on nutrient agar slants at 37°C. Each sample was sub cultured after 5 days.

2.2.1 Cell Suspension Preparation

Cell suspension was prepared by taking cultures from 3 days old agar slants, which were collected by adding sterile distilled water to each slant. The cell suspension was adjusted to a final concentration $1x10^8$ cells mL^{-1} by hemocytometer.

2.3 Leaching Method

Nutrient broth media was prepared for leaching. 10 grams of grinded coal samples of 20 and 40 mesh sizes were taken in 250 ml Erlenmeyer flasks. Nutrient broth was mixed with coal samples in ratio of 95% and 50%. The final volume of coal media mixture was adjusted to 100ml with distilled water. Samples were autoclaved at 121°C and 15 psi for 15 minutes. After autoclave cell suspension were inoculated in all flasks under Laminar flow cabinet. All samples were kept in incubator shaker at 37°C and 150 RPM for 72 and 120 hours. All samples were taken in triplicate.

Table 1: Composition of the Samples

No. of Samples	Particle Size (Mesh)	Weight of Coal (g)	Media/Distilled water ml/ml	Bacterial Solution (ml)	Incubation Time (Hours)
Sample 1	20	10	50/50	$1x10^8$	72
Sample 2	20	10	95/05	$1x10^9$	120
Sample 3	20	10	50/50	$1x10^8$	72
Sample 4	20	10	50/50	$1x10^8$	120
Sample 5	40	10	95/05	$1x10^9$	72
Sample 6	40	10	50/50	$1x10^8$	72
Sample 7	40	10	50/50	$1x10^8$	120
Sample 8	40	10	50/50	$1x10^8$	120

When the incubation time was over, all the samples were collected, filtered and dried at room temperature overnight. After drying process the analysis of sulphur and ash were carried out.

2.4 Reagents

All reagents used in the tests were analytical grade. The culture media were always made up with distilled water and, for laboratory testing, were always sterilized

3. RESULTS

Effect of different particle size on the percentage reduction of Sulphur contents from Coal were studied in this research study. Results were analyzed according to different particle sizes of coal; further incubation time was increased to check the percentage reduction of sulfur. Experimental results obtained from the set of experiments are shown in below Table 2. Four samples of different particle sizes were taken as; sample 1-4 with 20 mesh (0.841mm) particle size and samples 5-8 with 40 meshes (0.420mm), initial and final sulfur percentages are shown against each sample.

Table 2 : Results of Sulphur Leaching

No. of Samples	Initial sulphur %	After Leaching Sulphur %	Sulphur Reduced %
Sample 1	4.8	4.3155	10.09
Sample 2	4.8	3.966	17.38
Sample 3	4.8	4.1755	13.01
Sample 4	4.8	3.8155	20.51
Sample 5	4.8	4.26	10.09
Sample 6	4.8	4.1237	14.08
Sample 7	4.8	3.6685	23.87
Sample 8	4.8	3.6515	23.93

Above table 2. Shows a trend of sulfur reduction with the surface area of coal provided for leaching. From the experiment it is concluded that for larger particle size microbes was not found to be very effective for the Sulphur removal Erincin et al. [7] Suggested in their work while using 2% of inoculum concentration and 12 days of incubation time, 53% of Sulphur reduction has been observed on smaller particle size coal having 300µm particle size as compared to 500µm particle size coal. P. Fecko [8] studied the effect of different incubation time and was found that higher incubation time results in higher reduction of Sulphur compounds. Higher incubation is necessary because microbes needs time to adapt to the environment according to the condition given to them so generally microbes need more time in order to give maximum results.

Figure 1 shows the relation between particle size and Sulphur removal. Four samples of particle size 20 mesh were incubated for 3 day s (72hours) in a shaker incubator at 150RPM.

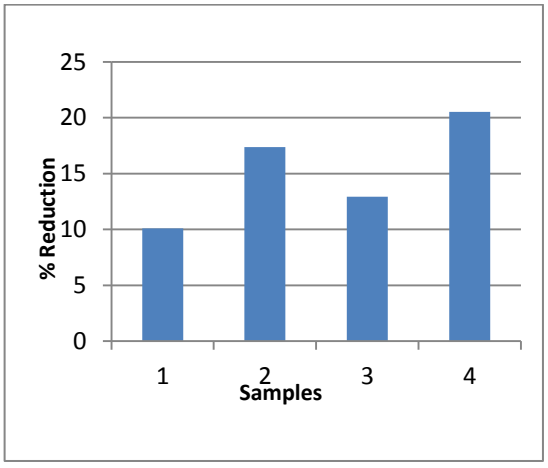

Figure 1: % Reduction OF Sulfur against each sample (1-4)

Results in above figure 1 shows that using 20 mesh particle size may reduce Sulphur from 4.8 to 4.3, which is almost 20%.

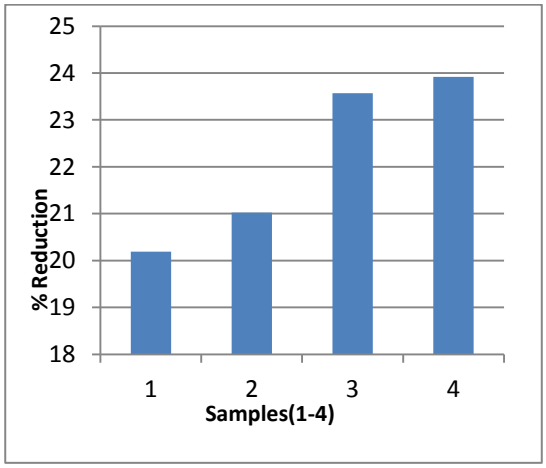

Figure 2: % Reduction of Sulphur against different samples

To further increase the Sulphur reduction, few more experiments were conducted using 40 mesh screen particle size. Figure 2 shows that decreasing the particle size may lead to increase its Sulphur reduction which is almost 24%. By increasing the surface area of coal it seems microbes get better chance to penetrate and extract what they need. Further size reduction may also increase Sulphur reduction.

Another factor which had greatly influenced for reducing Sulphur content was to increase the incubation period. Two different incubation times 72 and 120 hours respectively were studied using shaker incubator having rotation 150RPM and temperature 37°C to find out what actually is the impact of incubation period over the % reduction of Sulphur.

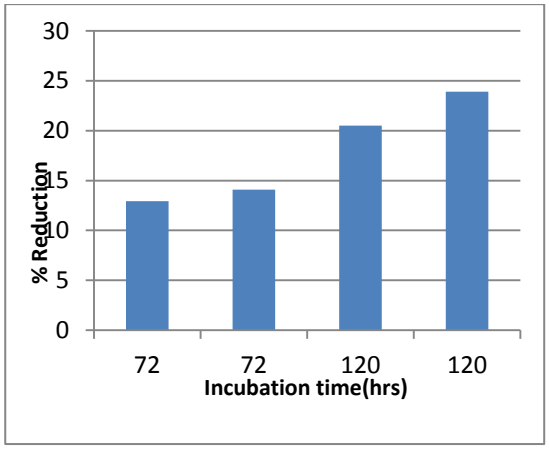

Figure 3: Incubation Time against Sulphur reduced

Figure 3 shows the removal of Sulphur against the incubation time. % Reduction of Sulphur against 120 hours (5days) is more as compare to 72 hours (3 days) incubation period. With increase in incubation time Sulphur reduction is higher.

4 CONCLUSION

The aim of the work was to investigate the possibilities of the application of bacterial leaching for desulphurization of Balochistan coal. Results indicate that for particle size 40 mesh it is possible to remove Sulphur by bacterial leaching more effectively as compared to 20 meshe. Incubation time is another factor which actually plays an important role in reducing the Sulphur contents, increasing incubation time may lead to higher removal of Sulphur.

It was also observed that the same species of bacteria may lead to ash reduction from the given samples of coal, which can be studied further.

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