Mansoura Engineering Journal

Volume 14 | Issue 1 Article 22

5-25-2021

# Regeneration of Soot Produced from Partial Oxidation of Natural Gas.

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# REGENERATION OF SOOT PRODUCED FROM PARTIAL OXIDATION OF NATURAL GAS

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## ABSTRACT

*Soot produced as a byproduct from partial oxidation of natural gas has been thermally and catalytically regenerated. The regeneration was assessed by comparing with powdered activated carbon (PAC). Significant parameters for regeneration were temperature, time of heating, kind and proportion of additives and particle size. Through this investigation soot with particle sizes < 200 μm, heated to 500 °C for half an hour and mixed with acetone (20 part acetone + 80 part soot on weight basis) was 122 % more efficient than PAC, whereas addition of glycerine (30 part glycerine + 70 part soot ) gave 113 % efficient than PAC on the basis of the decolorization of a standard methylene blue solution. The same samples were applied for the decolorization of glycerine and gave a decolorizing power ratio of 1.17 and 1.10 (relative to PAC ) respectively.*

# تنشيط السناج الناتج من الاكسدة الجزئية للغاز الطبيعي

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## خلاصـــة

في هذا البحث تم دراسة أنسب الظروف لتنشيط السناج الناتج من الاكسدة الجزئية للغاز الطبيعي وذلك بالتسخين وبإضافة بعض الحوامل المساعدة . والسناج يشكل عبئاً على مصانع الأسمدة حيث أنه مصدر للتلوث البيئي . والهدف من هذه الدراسة هو تحديد إمكانية إستخدام السناج المنشط – بدلاً من الفحم النامي المنشط – في صناعات عديدة مثل تبييض الجلسرين والسكر ..الخ ومعالجة مياه الصرف الصحي والصناعي . ولقد بنيت عملية التنشيط على أساس المقارنة مع الفحم النامي المنشط في إزالة لون أزرق الميثيلين وفي تبييض الجلسرين . ولقد وجد أن الحوامل المؤثرة على عملية تنشيط السناج هي درجة حرارة التسخين وزمن التسخين ونوع وكمية العامل المساعد المستخدمة مثل الجلسرين والأسيتون .

ولقد أوضحت هذه الدراسة أن السناج ذو حجم حبيبات أقل من ٢٠٠ ميكرومتر والمضاف إليه الأسيتون بنسبة ٢٠٪ بالوزن عند التسخين لمدة نصف ساعة عند درجة حرارة ٥٠٠ م يعطي كفاءة في إزالة لون أزرق الميثيلين تعادل ١٢٢ ٪ من الفحم النامي المنشط بينما السناج المخلوط مع الجلسرين بنسبة ٣٠ ٪ بالوزن يعطي كفاءة تعادل ١١٣ ٪ من الفحم النامي المنشط . ونفس العينات من السناج استخدمت في تبييض الجلسرين وكانت نتائجها تعادل ١٫١٧ و ١٫١ مرة قدر الفحم النامي المنشط على الترتيب .

## INTRODUCTION

Soot is produced as a byproduct from the partial oxidation of natural gas. Talkha Fertilizers and Chemical Plants (TFCP) produced about 90 tons per year from the partial oxidation of natural gas - taken from Abou Madi fields - for obtaining hydrogen. The produced hydrogen is exploited for ammonia production which is the key intermediate for the production of nitrogen fertilizers such as urea and ammonium nitrate.

Till now, this soot has no beneficial uses and it imposes an environmental problem for the plant (TFCP). The only trial for exploiting this soot was for the reduction of high concentrations of ammonia - nitrogen from the industrial effluent of that plant [1], by adsorption technique.

Activated carbon is usually divided into two main classes :

1) Granular form which is used for adsorption of gases and vapors.

2) Powdered form which is widely exploited in decolourization and purification of many industrial products [2], such as :

- Refining of cane sugar, beet sugar, glucose and other sirups
- Refining oils, fats, and waxes such as cottonseed oil, coconut oil, etc.
- Decolorizing industrial and pharmaceutical glycerine.
- Removing impurities from food products such as gelatin, vinegar, fruits juices and pectin.
- Removing impurities from pharmaceutical and other chemical products, including acids.
- Water purification for the removal of taste, odour and colour.
- Removing impurities from used oils, dry-cleaning solvents, etc.

Addition of powdered activated carbon to the aeration basin of an activated sludge treatment plant fed with dye-works waste waters increases the purifying capacity of the plant. Removal efficiency rises from 55.8 to 75.6 % ( COD ) and from 78.0 to 98.5 % ( $BOD_5$) and the nitrification-denitrification capacity of the system also increases [3].

Powered and granular activated carbon, have been applied, recently [4], to remove toxicity from drinking water containing cyanobacterial blooms, with and without chlorination, alum flocculation and polyelectrolyte addition

In Egypt, powdered activated carbon is imported from abroad about 10,000 Egyptian pounds per ton, (prices of 1988). For example, soap firms import about 20 tons of powdered activated carbon per year for decolourizing industrial and pharmaceutical glycerine [5].

The aim of the undertaken work is to asseses the feasibility using soot as an adsorbent in liquid-phase adsorption after special treatment with some additives. In performing this work a comparison between the treated soot and powdered activated carbon is held for their decolourizing power for methylene blue as specified in different standards [6].

**Experimental**

Soot produced from the partial oxidation of natural gas was dried, crushed in a mortar and sieved to obtain powdered soot with particle size less than 200 $\mu$m. Additives of glycerine or acetone with different proportions were added, a slurry of the prepared samples in water was formed by the aid of magnetic stirrer. Water was evaporated in an oven till dryness (at 100°C).

Different samples from either soot or soot blended with

acetone or glycerine as indicated in Table (1) have been prepared

**Table (1): Key to Prepared Samples**

| Sample code | Composition (on weight basis) |
|---|---|
| S00 | Soot alone without additives |
| SG10 | 90 parts soot + 10 parts glycerine |
| SG20 | 80 parts soot + 20 parts glycerine |
| SG30 | 70 parts soot + 30 parts glycerine |
| SA10 | 90 parts soot + 10 parts acetone |
| SA20 | 80 parts soot + 20 parts acetone |
| SA30 | 70 parts soot + 30 parts acetone |

These samples were heated in a muffle furnace at specified temperature ranged from 350 to 700°C at different heating times.

Adsorption capability of the regenerated soot was assessed by comparing the adsorption characteristics with powdered activated carbon-expoiled in glycerine bleaching-with respect to the decolourization of both methylene blue solution and distilled glycerine according to the Japanese Industrial Standard JISK-1470 [6].

Decolourization of methylene blue solution was measured colorimetrically by measuring the absorbancy on a spectrophotometer (Shimadzu model UV-120-02, Japan) at a wave length of 665 nm. Calibration curves of decolourization produced from different masses of PAC were constructed in two different mass ranges. Fig. (1) illustrates the calibration curve for large masses of PAC where Fig. (2) and Fig (3) illustrate the calibration curve obtained for low masses of PAC.

Decolourization of distilled glycerine was performed by adding about 0.2% soot to glycerine and heating at 80°C for about 2 hours. The decolorizing power ratio of the samples relative to PAC was then found.

**Results and Discussions**

Preliminary investigation on soot without any size classification showed that its decolourising power towards methylene blue is greatly affected by temperature and heating time. At begining, addition of glycerine or acetone (heating at 350°C for different times 0.5, 1, and 2 hours) does not increase the decolourizing power of soot, but addition of both produce a negative effect. The maximum efficiencies obtained were lean compared with PAC. They were 38% ,28% and 20% for S00, SG30 and SA30 respectively.

Increasing the temperature to 500°C improves the efficiency of samples blended from soot and glycerine and sample SG30 gave the best results of the whole samples on heating for half an hour. Results obtained from other samples are given in Table (2)

Table(2): Percentage relative efficiency of regenerated soot to PAC for decolourization of methylene blue solution.

| Type of soot | without sieving | | Soot with particle size < 200 μm | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temp.(°C) | 350 | | 350 | | 500 | | 600 | | 700 |
| Timer(hr) | 0.5 | 1 | 1 | 2 | 0.5 | 1.5 | 0.5 | 1 | 1.5 |
| S00 | 33 | 18 | 28 | 33 | 93 | 89 | 93 | 75 | 58 |
| SG10 | 37 | 45 | 31 | 43 | 89 | 95 | 89 | 57 | 2 |
| SG20 | 54 | 65 | 28 | 37 | 92 | 82 | 90 | 68 | 0.4 |
| SG30 | 46 | 66 | 26 | 57 | 113 | 90 | 75 | 45 | 0.3 |
| SA10 | 29 | 49 | 26 | 33 | 88 | 86 | 108 | 60 | 4 |
| SA20 | 2 | 1 | 27 | 33 | 122 | 88 | 98 | 76 | 5 |
| SA30 | 2 | 3 | 30 | 36 | 58 | 87 | 43 | 77 | 5 |

Another phase of this investigation was carried out on soot after grinding and sieving to particle size < 200 μm. In this

phase the results obtained were regular and the studied parameters were critical . The whole results obtained from the variations of those parameters are given in Table (2). The results indicate that it may be possible to regenerate soot to be more active than the classic powdered activated carbon. Best results in this investigation were obtained from samples SA20 and SG30 on heating at 500$^{o}$C for half an hour. They were 122 % and 113 % more efficient than PAC respectively. Other samples, also, have the best results at these conditions.

The main prospect from this investigation is to study the feasibility of substitution of the regenerated soot instead of PAC in different applications. One of the important uses of PAC is the decolourization of distilled glycerine, therefore the samples that gave reasonable results from the decolourization of methylene blue were applied in the decolourization of distilled glycerine. The results were recorded relative to PAC and are given in Table (3)

Table (3): Decolorizing power of regenerated soot for distilled glycerine relative to PAC.

| Sample | S00 | SG10 | SG20 | SG30 | SA10 | SA20 |
|---|---|---|---|---|---|---|
| Decolorizing powere ratio | 0.95 | 0.04 | 0.96 | 1.10 | 0.85 | 1.17 |

Results given in table (3) indicate that it is possible to apply SA20 or SG30 efficiently. One advantage of addition of glycerine is that the regeneration of the exhausted soot may not need any treatment other than heating. Addition of acetone facilitates mixing with water.

Conclusions

Soot produced from partial oxidation of natural gas can be thermally and catalytically regenerated. The addition of glycerine or acetone improves its activity significantly. Its activity relative to powdered activated carbon was assessed by the decolourization of methylene blue solution.

Addition of glycerine to soot ( 30% by weight ) and heating at 500 °C for half an hour produced soot with 113% more efficient than PAC whereas addition of acetone ( 20% by weight ) at the same conditions produced soot with 122% more efficient than PAC.

Temperature, time of heating and the proportion of acetone or glycerine added are critical parameters. Generally best results were obtained on heating at 500 °C.

Regenerated samples were utilized for the decolourization of distilled glycerine and gave results in correspondence with that obtained from decolourization of methylene blue solution.

This investigation amble the way for the application of soot produced from partial oxidation of natural gas as a substituent for PAC in different industrial applications.

References:

[1] Abdallah, A. M.; Khalifa, M. E.; Rashed, I. G.; "*Removal of environmental ammonia pollution from Talkha Fertilizers and chemical plants using soot*"; The 2nd Conference on Chemistry and its Application; 27-29 Sept. (1988), Faculty of Science, Mansoura University.(In press).

[2] Shreve, R. N.; Brink, J. A.; "Chemical Process Industries"; Mc Graw-Hill Int. Book Co.(1977).

[3] Specchia, V.; Gianetto, A.; "*Powdered activated carbon in an activated sludge treatment plant*"; Water Research; Vol. 18, No. 2, pp. 133-137; (1984).

[4] Falconer; I. R.; Runnegar, M. T. C.; Buckley, T.; Huyn, V. L.; Bradshaw, P.; "*Using activated carbon to remove toxicity from drinking water containing cyanobacterial blooms*"; Journal of American Water Works Association (AWWA), pp. 102-105, Feb. (1989).

[5] Bastawissi, A. E.; Rashed, I. G.; "*Regeneration of powdered activated corbon exhausted during glycerine bleaching*"; Mansoura Engineering Journal, (MEJ); Vol. 13, No. 2, pp. 49-58; (1988).

[6] Japanese Industrial Standard; "*Testing methods for powdered activated carbon*"; JIS - K - 1470; (1967).

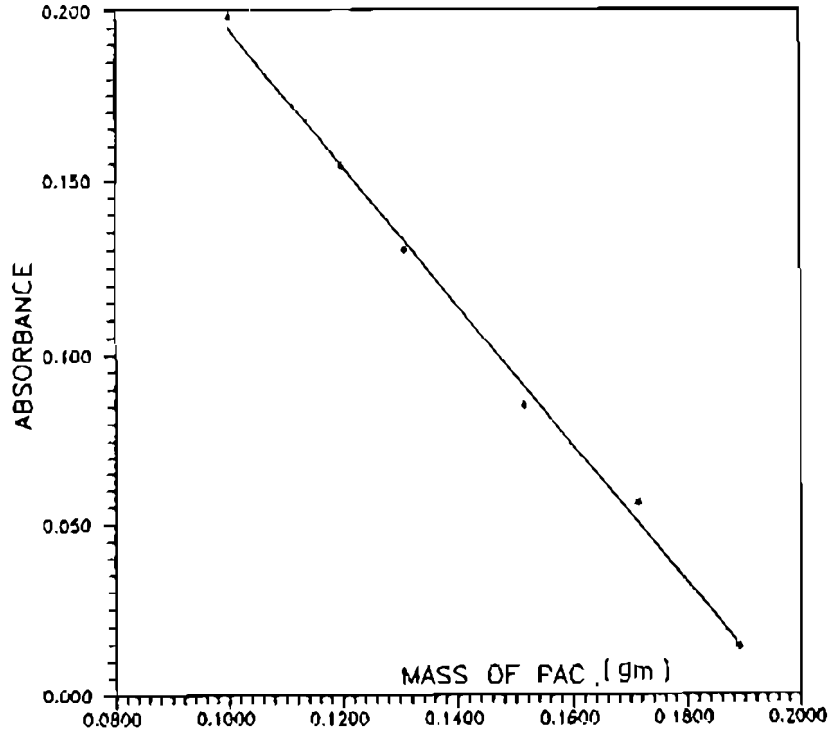


Fig.(1): Plots of Absorbance from Treated Methylene Blue with PAC Against Mass of PAC Used.

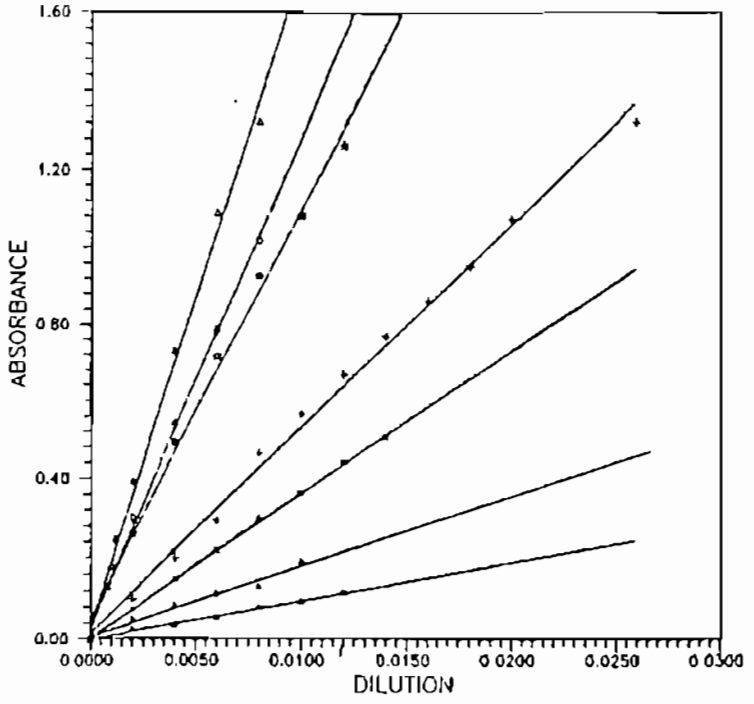


Fig.(2) Absorbance of Treated Methylene Blue With (PAC) at Different Dilutions

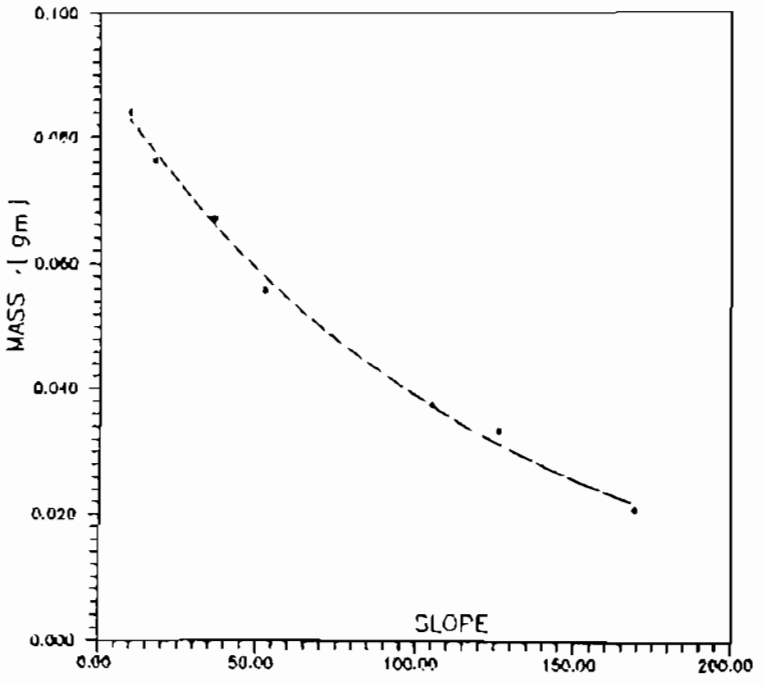


Fig.(3): Plots of PAC Mass vs. Slope of Lines Produced from Fig.(2)

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