

ACTIVE CARBON FROM STRAW WASTE

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Introduction

The increasing variety and amount of potentially hazardous impurities in water supplies together with increasing stringency of the legislation concerning water purity has led to increasing use of activated carbon, in either granular or powdered form for water purification. The problems associated with the use of activated carbon are largely economic due to its high cost. This leads to the need for regeneration of the spent carbon and this additional processing cost plus the loss of material during regeneration strongly affects the economic viability of the use of large quantities of activated carbon.

There is a clear need for a cheaper, more cost effective, product which could possibly be used on a throw-away basis. To achieve this requires an inexpensive feedstock for the manufacture of the activated carbon. One possible solution is therefore to use a waste organic material as the feedstock with the aim of producing a relatively cheap carbon of adequate adsorptive capacity for water treatment. Straw waste has been identified as a possible source of the required raw material since it is cheap, abundant (there is a surplus of several million tonnes/p.a. in the UK) and can present a problem in terms of its disposal. The objective of this investigation was to determine if a disposable activated carbon suitable for water treatment, and in particular for the removal of organic substances, can be produced from straw waste and if so, to formulate the most appropriate production conditions.

Experimental

Activated carbon preparation

Samples of straw (approximately 50g) in the form of briquettes of various sizes and density were used in the as-received, air-dried condition. Other straw waste in the form of husks and nodes obtained as waste from various derived grain products were also used. They were carbonised in a tube furnace

in a stream of oxygen free nitrogen at a heating rate of 5°C/min to temperatures between 700-900°C the final temperature being maintained for 2h. Cooling was also carried out in flowing nitrogen. The carbons so obtained were subsequently activated at temperatures between 700-900°C in a stream of moisture laden nitrogen, the degree of activation being controlled by varying the gas flow rate (upto 200 ml/min) and the activation time (6-24h). The samples to be activated (about 15g) were in the form of particles of about 6mm size and at each stage the yield of carbon was determined.

Surface area measurements

Surface areas and pore size distributions were determined using an automatic analyser using nitrogen adsorption at 77K. Both BET and Langmuir surface areas and Langmuir and BJH pore size distributions were calculated.

Determination of iodine number

The iodine number for selected samples of the various activated carbons produced was determined by means of the standard method as described in ASTM D4607-86. This method determines the ability of the carbon to adsorb a large molecular species, in this case iodine, from aqueous solution and is based on a three point adsorption isotherm.

Phenol adsorption

Samples of activated carbon (50-500 mg of particle size 53 to 210 µm) were contacted with dilute aqueous solutions of phenol and p-chlorophenol for a period of 2h, the concentration of the phenols being determined spectrophotometrically at 270 and 274 nm respectively. The contact time of 2 hours enabled pseudo-equilibrium curves to be determined as a means of comparing the adsorptive capacity of the carbons.

Results and discussion

The yield of carbon from the heat treatment of the various straw wastes varied from about 30 wt% for

the 800°C carbonisation of briquetted straw to 23 wt% with barley and oats nodes. The degree of compaction of the briquettes varied from tightly bound hydraulically pressed cylindrical briquettes to loosely compacted blocks but this had no influence on the carbon yield although exerting some effect on the physical nature of the carbon obtained.

Activation resulted in a further weight loss dependent on the activation conditions, increasing activation time, temperature, amount of water vapour in the activating gas stream and the gas flow rate diminishing the carbon yield, Table 1. Consequently the overall carbon yield varied from about 25 to less than 5 wt% but no overall relationship could be established to predict the yield.

All the activated carbon samples yielded type 1 isotherms and BET surface areas upto 900 m²/g were attained at the expense of very low carbon yields (the original carbons had surface areas less than 5 m²/g). The activation conditions to attain maximum surface areas varied with clear indications of a diminution of the surface area with increasing severity of activation beyond this, Table 1. Again no overall relation between the surface area and the carbon yield was found for all the samples produced although a general trend is exemplified by Figure 1 which includes data for fixed conditions of gas flow rate and water vapour content and various times and temperature. The iodine number varied in a similar manner to the surface area measurements with a maximum value of 880 (mg of iodine adsorbed per g of carbon) for a sample activated at 900°C for 16 hours.

As regards the adsorption of phenol and p-chlorophenol samples of carbon from straw with BET surface areas of 300-600 m²/g exhibited similar adsorption characteristics, in terms of both amounts adsorbed and rate of adsorption, to commercial active carbons prepared from coal and wood and only slightly inferior to shell-based carbons of much higher surface area [1].

The data obtained demonstrates the potential of the use of straw wastes for the production of active carbon suitable for water purification, although further research is required to formulate the conditions for a viable process.

References

1. M. Streat, J.W. Patrick and M.J. Comporro Perez, *WaterRes.* **29**, 467 (1995).

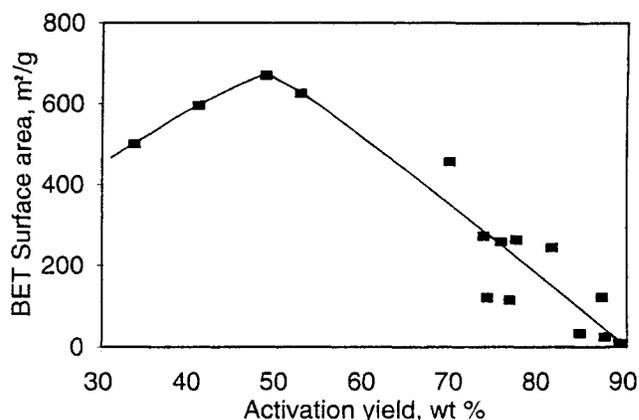


Fig.1 Relation between surface area and carbon yield.

TABLE 1. Example of carbon activation yields wt% and (surface areas m²/g)

Temperature °C	Time, h	Low water vapour content Flow rate, ml/min		High water vapour content Flow rate, ml/min	
		100	200	100	200
800	8	87.2 (122)	78.0 (428)	86.9 (273)	78.5 (356)
	16	81.5 (245)	75.0 -	79.4 (268)	55.0 (672)
	24	75.6 (259)	66.8 -	72.6 (315)	28.6 (813)
900	2	89.2 (9)	87.5 (18)	88.6 (22)	87.2 (32)
	4	87.5 (25)	85.7 (88)	89.9 (6)	72.4 (468)
	6	84.6 (34)	81.7 (172)	84.0 (134)	65.5 (469)
	16	77.4 (264)	72.1 (432)	83.7 (205)	27.7 (900)
	24	74.0 (121)	67.2 (320)	73.6 (283)	13.3 (678)