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# Granular Activated Carbon from Wood Originated from Tropical Virgin Forest

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## Abstract

**This research investigates several woods originated from trees of tropical virgin forest as raw material for the production of granular activated carbon. Mechanical strength of the activated carbons produced was related to wood hardness and lignin content but not to cellulose-lignin ratio. One of the eight woods studied (Dividivi) produced an activated carbon with a high mechanical strength similar to that produced from coconut shell, taken as a standard. Dividivi is also suggested as promissory for desert greening.**

## Keywords

**Activated Carbon, Tropical Wood, Granulated Activated Carbon, Coconut Shell, Dessert Greening, Dividivi**

## 1. Introduction

Selecting arboreal species prototypes to harvest for particular wood applications is a matter of extensive technology spectra. For example, wood as building material for houses, furniture, artifacts like baseball bats, boats, etc. Regarding present studies, wood is also employed for activated carbon manufacture for applications such as: Filtering air, solvent extraction, automotive pollution control, beer processing, air separation by PSA process, aqueduct's water purification, gold mining, etc. (Bansal et al., 1988).

Certain arboreal species (e.g., eucalyptus, poplar), particularly those genetically modified to achieve fast growing, are intended for afforestation (also referred to as desert greening), aiming to create timberland for renewable bioenergy for substituting fossil energy and, therefore, contributing to offset global warming. Certainly, sustainable global energy supply, based on lignocelluloses' harvest derived from afforestation of world's degraded areas like deserts and others undergoing desertification, may be realized in some decades (Metzger &

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Hüttermann, 2009). Arid lands represent almost one-third of total world's nonpermafrost land, a promising sink for atmospheric carbon if photosynthesis is activated by means of afforestation assisted by both agrichar application and irrigation; the agrichar being a byproduct from either wood processing in biorefineries or from fossil hydrocarbon processing (Laine, 2012); and the irrigation powered by renewable energy (Al-Karaghouli et al., 2009).

In the case of granular activated carbon (GAC), a high mechanical strength of the granules is an important parameter to avoid operational problems because of granular size reduction by rupture. Coconut shell is well known as one of the best raw materials for the manufacture of microporous GAC with good particle mechanical strength (Heschel & Klose, 1995); however, production of agricultural byproducts like coconut shell is insufficient to cover the increasing world's demand of GAC. For this reason, wood or coal is also employed for GAC manufacture, but in these cases the granules are generally produced by pelletizing the wood or coal char powder composed of a binder to ensure proper mechanical strength of the resulting pellets (Amaya et al., 2007; Rubio et al., 1999).

Certain tree species are known to yield very hard woods that could produce GAC with better mechanical strength using similar processing than that used for coconut shell as raw material; in addition, arboreal species may offer a larger amount of lignocellulose raw material than the coconut palm.

Within the above scope, the objective of this research was to investigate several woods originated from trees of tropical virgin forest as raw material for GAC manufacture, and to compare them with GAC obtained from coconut shell using the same activation procedure.

## 2. Experimental

Samples of wood were cut into cubes 2 × 2 × 2 $cm^3$ and submitted to activation (i.e., generation of microporosity's surface area) by means of partial gasification using a flow of $CO_2$ at 800˚C for 2 hours, employing a tubular furnace. Coconut shell with particle size 0.1 to 0.3 cm and average particle volume = 1.5 $cm^3$ were also activated in the same way.

Raw material cellulose and lignin content were measured using the methods of Seifert and Klason. Hardness was measured with a meter type D (ASTM D2240). Abrasion resistance test was carried out according to AWWA standard for granular activated carbon B604-74. Surface area of the ground activated carbon was measured following BET method using a Micromeritics ASAP 2010 apparatus.

## 3. Results and Discussion

Some characteristics of the raw material employed are shown in **Table 1**. Wood samples: 1, 2 and 3 can be considered soft woods, whereas samples 4 to 8 are wood as hard as the coconut shell. Also, the coconut shell has lignin content higher than all off the wood employed.

Notice that some tree species such as pine, eucalyptus, poplar, mahogany, oil palm, rubber tree, etc., not included in this study, are worldwide employed for reforestation. In contrast, the tree species indicated in **Table 1**, are actually employed in Venezuela and other tropical American countries for applications such as house building, furniture, etc.; but generally, none of them is harvested from reforested forest but from virgin forest. Such tropical tree harvesting in a virgin forest is complicated by the fact that, as a difference from temperate and boreal forests characterized by predominant timberland species, biodiversity is so high in tropical forest that only a relative small number of each species are dispersed along the forest area. Certainly, reforestation or afforestation using other species different than the conventional pine, etc., cited above, is an interesting matter for further research.

**Table 2** suggests that soft woods (1, 2, and 3) may not be suitable for the production of GAC by the presently proposed activation of wood granules, as long as GAC strength (hardness and abrasion resistance) is considerably deficient in those cases. Accordingly, wood hardness appears to be one limiting parameter to achieve a good strength quality GAC.

The other limiting parameter is probably the lignin content, although there are remarkable difference between the cellulose/lignin ratio of the woods (around 1.2 - 1.8, calculated from data in **Table 1**) and that of the coconut shell (0.7), however, the hardness and abrasion loss properties of the activated carbons obtained appear not to depend on this ratio, but on the lignin content. Certainly, among all wood samples Dividivi was the one with the highest lignin content; suggesting than lignin functioning as a binder of the cellulose fibers, may also suppress

**Table 1.** Characteristics of woods and coconut shell.

| ## | Tree local name | Tree taxonomic name | Density ($g/cm^3$) | Cellulose (wt%) | Lignin (wt%) | Hardness |
|---|---|---|---|---|---|---|
| 1 | Apamate | *Tabebuia rosea* | 0.5 | 44.8 | 33.4 | 45 |
| 2 | Saquisaqui | *Bombacopsis quinata* | 0.6 | 46.3 | 36.2 | 50 |
| 3 | Saman | *Pithecelobium saman* | 0.7 | - | - | 55 |
| 4 | Congrio | *Acosmium niteus* | 0.9 | 50.5 | 28.0 | 75 |
| 5 | Dividivi | *Caeselpinia coriana* | 1.3 | 49.1 | 38.7 | 85 |
| 6 | Palo Brasil | *Haematoxilon brasileto* | 1.3 | 44.1 | 35.9 | 80 |
| 7 | Araguaney | *Tabebuia crysanta* | 1.1 | 46.2 | 34.6 | 80 |
| 8 | Algarrobo | *Hymenea courbaril* | 1.1 | 42.9 | 33.5 | 75 |
| 9 | Coconut shell | - | 1.2 | 29.9 | 45.4 | 80 |

**Table 2.** Characteristic of the activated carbons.

| # | Yield (%) | Volume decrease (%) | Hardness | Abrasion loss (%) | Surface area ($m^2/g$) |
|---|---|---|---|---|---|
| 1 | 11 | 68 | 10 | 35 | 650 |
| 2 | 21 | 49 | 15 | 18 | 540 |
| 3 | 16 | 55 | 25 | 8 | 640 |
| 4 | 23 | 58 | 40 | 1.3 | 510 |
| 5 | 29 | 52 | 55 | 0.9 | 420 |
| 6 | 28 | 48 | 30 | 1.9 | 490 |
| 7 | 18 | 69 | 40 | 3.0 | 580 |
| 8 | 24 | 57 | 40 | 1.9 | 480 |
| 9 | 24 | 60 | 55 | 0.5 | 490 |

fracture of the carbonized framework.

It is also noticed that surface area and yield are small respect to those normally obtained when using either a dehydrating agent (e.g., $H_3PO_4$) impregnated on the lignocellulose raw materials (Laine & Yunes, 1992), or a gasifying catalyst (e.g., KOH) impregnated on coke raw materials (Derbyshire et al., 2000). In these cases surface areas are generally above 1000 $m^2/g$ and yield near to 40 wt.%.

It may be remarked that best tree presently found for GAC manufacture: Dividivi, is well adapted to xerophilous environments, therefore, being suitable for desert greening. In addition, tannins can be extracted from its pods for use in leather production (Perez-Tello & Quintana-Hernández, 1995).

## 4. Conclusion

Present results suggest that certain hard woods (e.g., Dividivi) could substitute coconut shell for producing good quality GAC from the granulated raw wood. A more complete optimization study is recommended to be carried out, particularly impregnating the granulated wood with a dehydrating agent such as $H_3PO_4$ in order to increase yield and surface area. The use of Dividivi for desert greening is proposed as a matter for further research.

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