# Three-Dimensional Hierarchical Porous Carbon Derived from Natural Resources for Highly Efficient Treatment of Polluted Water

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**Research Article**

**Keywords:** Biomass-materials; porous carbon; methylene blue; waste water

**Posted Date:** April 26th, 2021

**DOI:** https://doi.org/10.21203/rs.3.rs-443489/v1



**Version of Record:** A version of this preprint was published at Environmental Sciences Europe on August 21st, 2021. See the published version at https://doi.org/10.1186/s12302-021-00527-6.

# Abstract

In this work, a series of three-dimensional (3D) porous carbon nanomaterial with large specific surface area and hierarchical pores were selectively prepared from biomass with varied properties obtained by tuning the carbonization temperature and activation agent. The optimized carbon sample (PC-500-6) exhibits a typical hierarchical porous structure with a high specific surface area (3203 $m^2/g$) and pore size distribution in the range 0.8 to 3.0 nm, which shows excellent adsorption performance for methylene blue (MB) from an aqueous solution. The maximum adsorption capacity even reaches 917.43 mg/g, which is among one of the best results up to now. Through analysis of the adsorption data, it is found that the corresponding adsorption kinetic fits the pseudo-second-order model very well. The present results demonstrate that biomass-derived hierarchical porous carbon has a real potential application for wastewater treatment.

**Background:**

Dealing with the ever-increasing water pollution has become an urgent global problem, especially the organic containing polluted water. The physical adsorption has become one of the most popular ways for removal of organic dyes from wastewater due to its low cost as well as high efficiency. However, the adsorption performance is still limited by the low specific surface area (SSA) and unsuitable pore size. Hence, it is still a challenge to synthesize active carbon (AC) with high SSA, suitable pore size distribution as well as low cost for polluted water treatment. Here, we report an efficient method to prepare AC with large SSA from jujube for removal of MB in aqueous solution. The present results demonstrate that biomass-derived hierarchical porous carbon has a real potential application for wastewater treatment.

**Results:**

The as-prepared hierarchical porous structure carbon material (PC-500-6) shows a high specific surface area (3203 $m^2/g$) and pore size distribution in the range 0.8 to 3.0 nm, while exhibits an enhanced adsorption performance for methylene blue (MB) from an aqueous solution. The maximum adsorption capacity even reaches 917.43 mg/g, which was calculated from Langmuir model. Through analysis of the adsorption data, it is found that the corresponding adsorption kinetic fits the pseudo-second-order model very well.

**Conclusions:**

It can be concluded that the adsorption of MB has a strong correlation with SSA, pore size distribution as well as the pore volume. The present study paved a practical way for wastewater treatment by using biomass-derived hierarchical porous carbon.


# Full Text

This preprint is available for download as a PDF.

# Figures

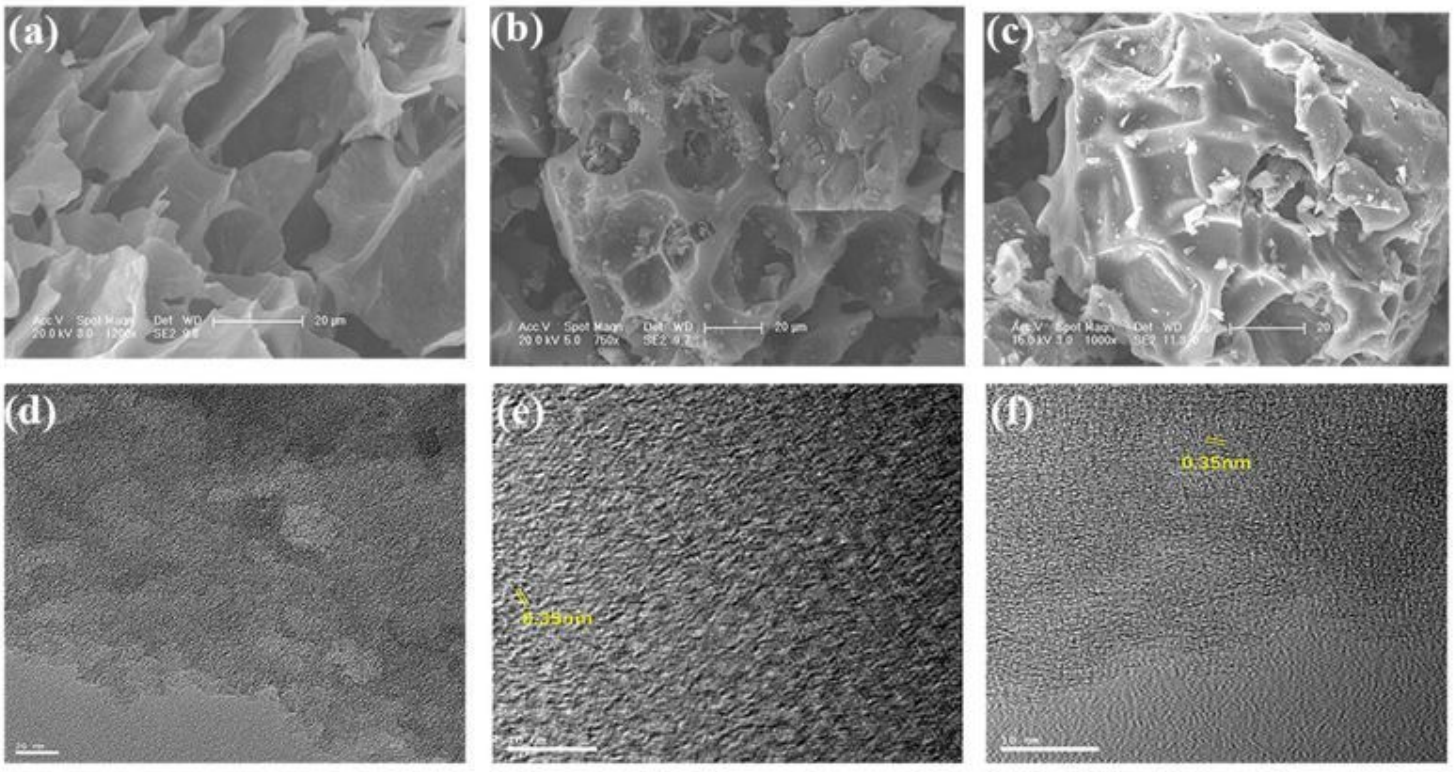
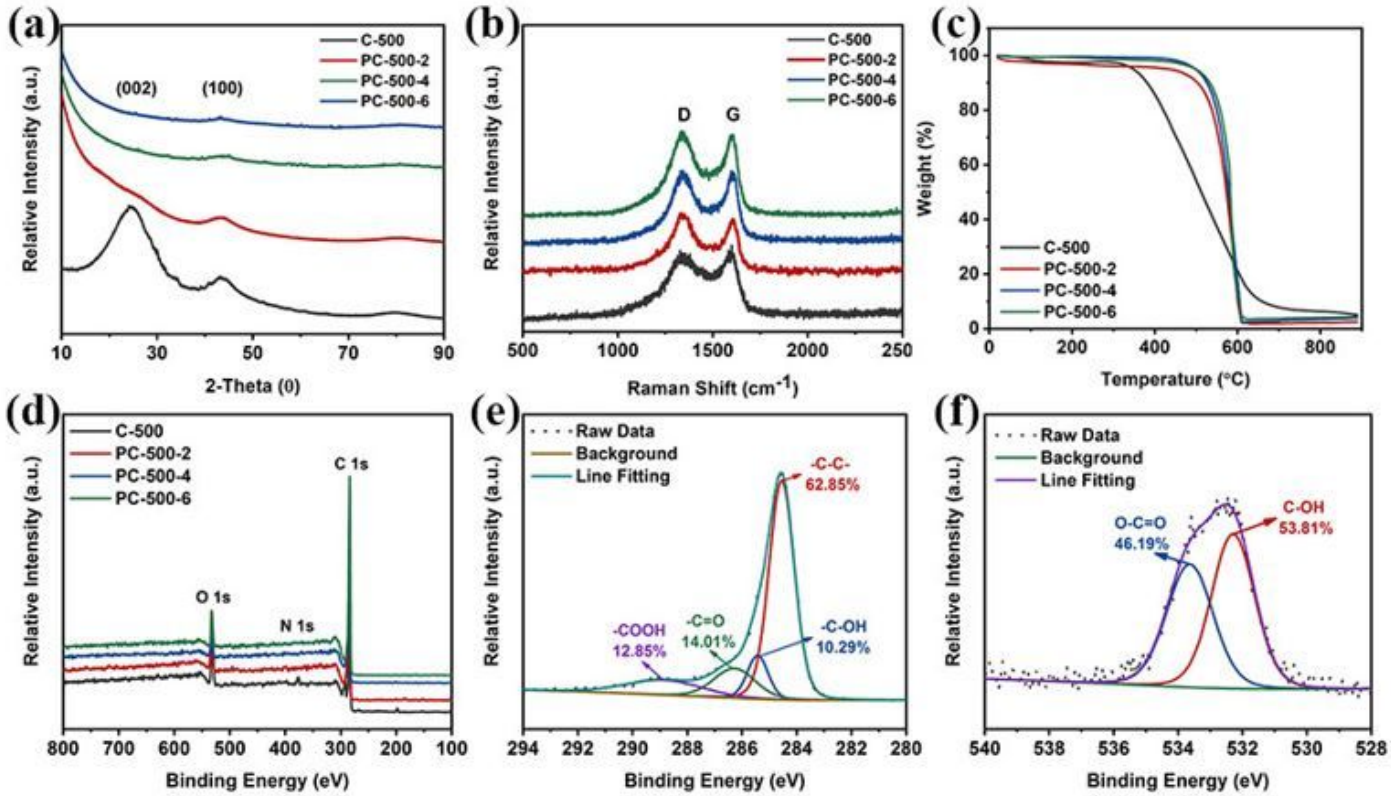


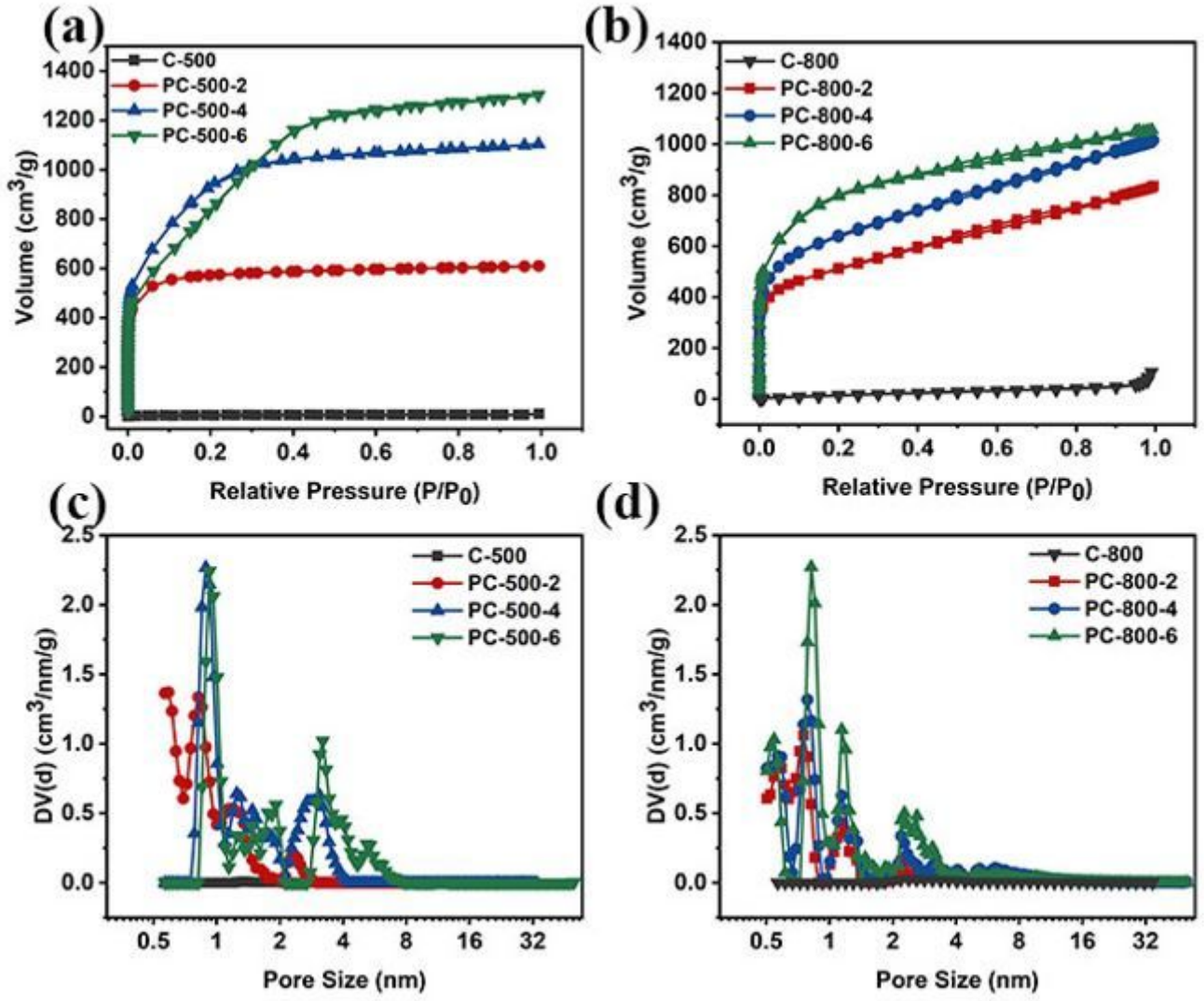

**Figure 1**

SEM images of (a) C-500 and (b) PC-500-6 and (c) PC-800-6; HRTEM images of (d) C-500 and (e) PC-500-6 and (f) PC-800-6.



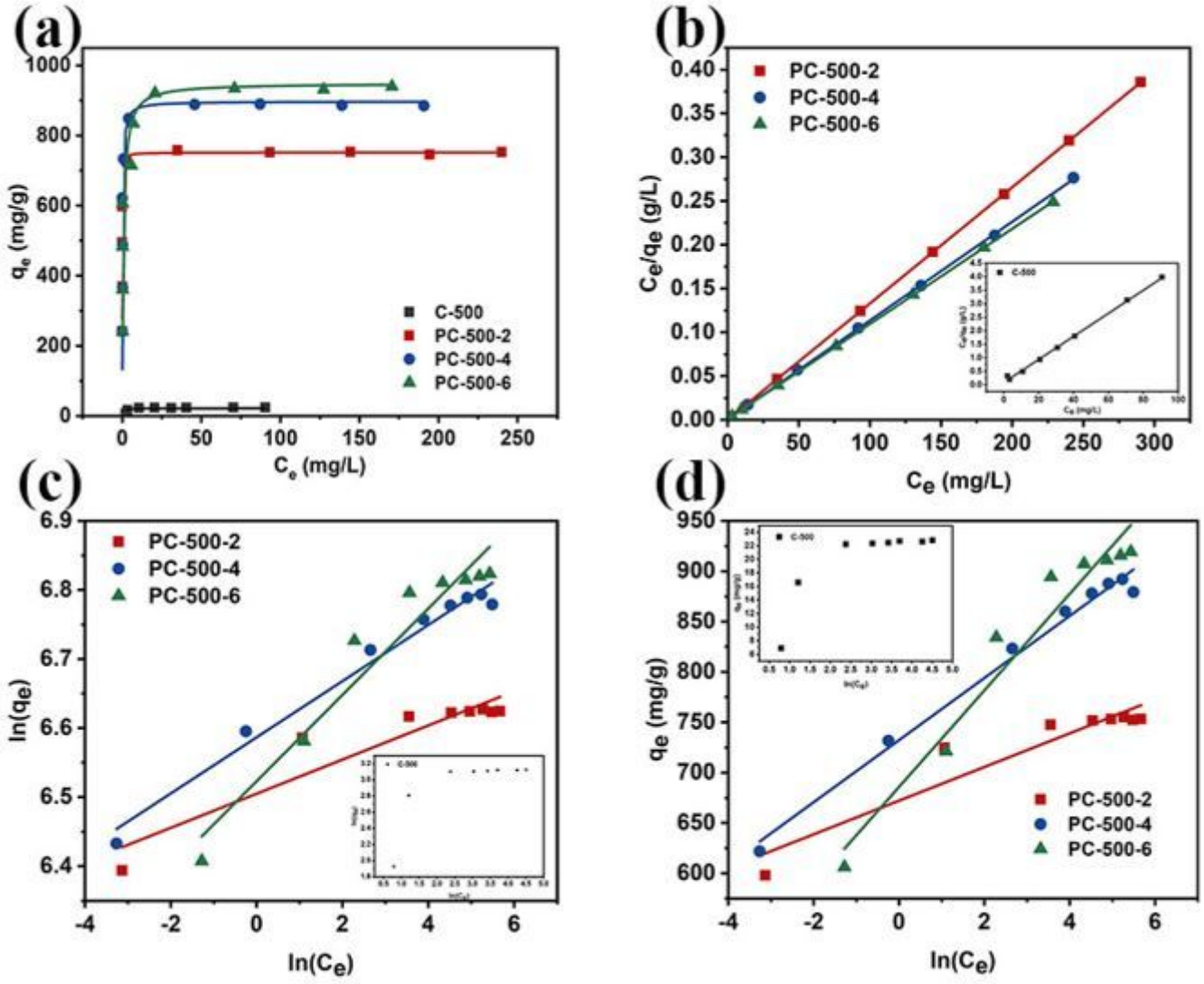

## Figure 2

(a) XRD curves, (b) Raman spectra, (c) TGA curves and (d) full XPS spectra of C-500 and PC-500-Y. High-resolution XPS spectra of PC-500-6 (e) C1s and (f) O1s.




## Figure 3

N2 adsorption/desorption isotherms of (a) C-500 and PC-500-Y, (b) C-800 and PC-800-Y. Pore size distribution of (c) C-500 and PC-500-Y, (d) C-800 and PC-800-Y.




## Figure 4

(a) Equilibrium adsorption isotherms, (b) Langmuir, (c) Freundlich (d) and Temkin isotherms of MB on C-500 and PC-500-Y. (20 mg of C-500 or PC-500-Y added to a 50 ml MB solution (10-80 or 250-600 mg/l) at a designated concentration after stirring for 12 h.)

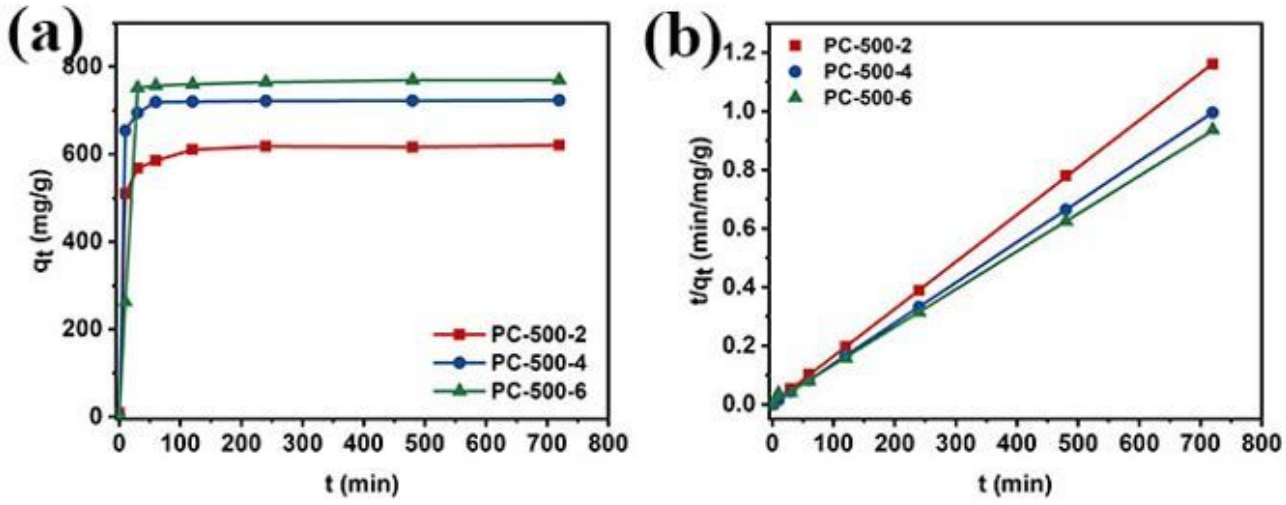



Figure 5

Kinetic curves of (a) the pseudo second-order kinetic model (b) PC-500-Y for the adsorption of MB. (Experimental conditions: MB concentration was 250 mg/l for PC-500-2, 300 mg/l for PC-500-4 and PC-500-6 and adsor¬bent concentration was 20 mg/l).

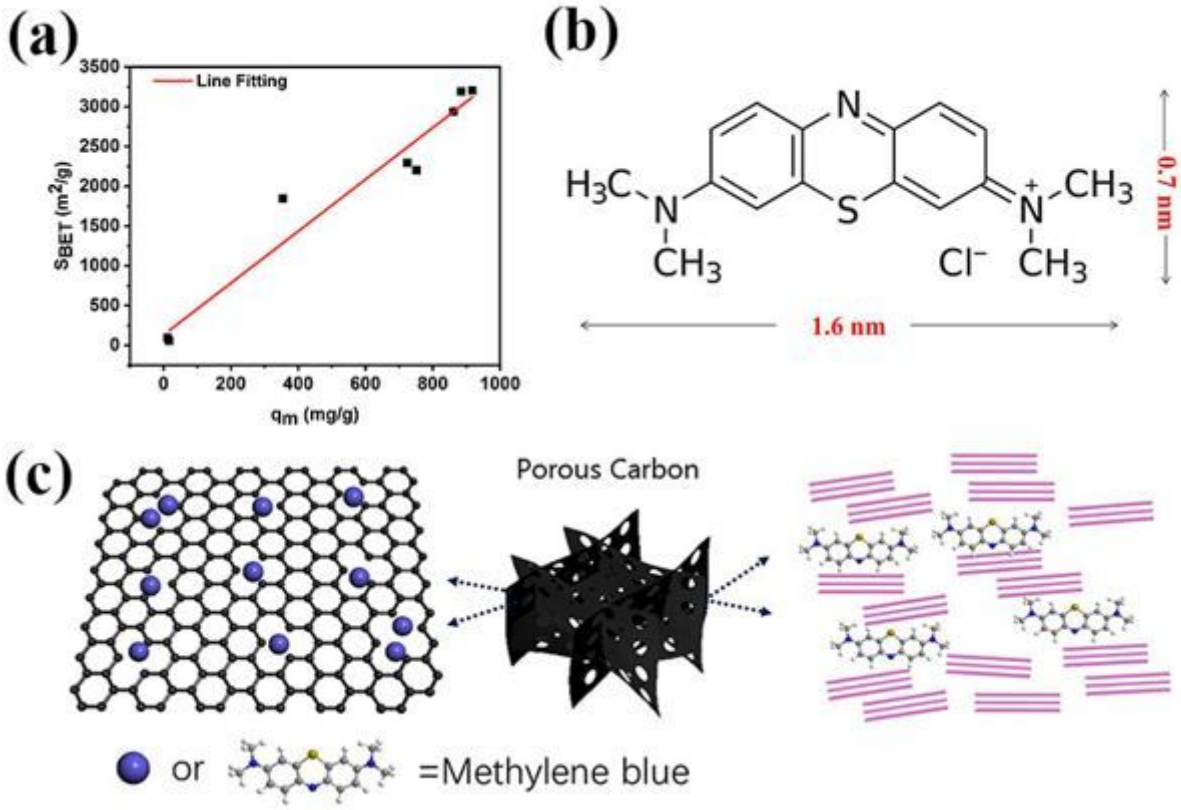



Figure 6

(a) Correlations between the qm and SBET. (R2 = 0.95022), (b) molecular structure and dimensions of MB, (c) a scheme for MB adsorption in the 3D porous carbon.

## Supplementary Files

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- SupplementaryMaterial.docx