ACTIVATION OF CHARS DERIVED FROM HIGH TEMPERATURE CELLULOSIC BIOMASS PYROLYSIS

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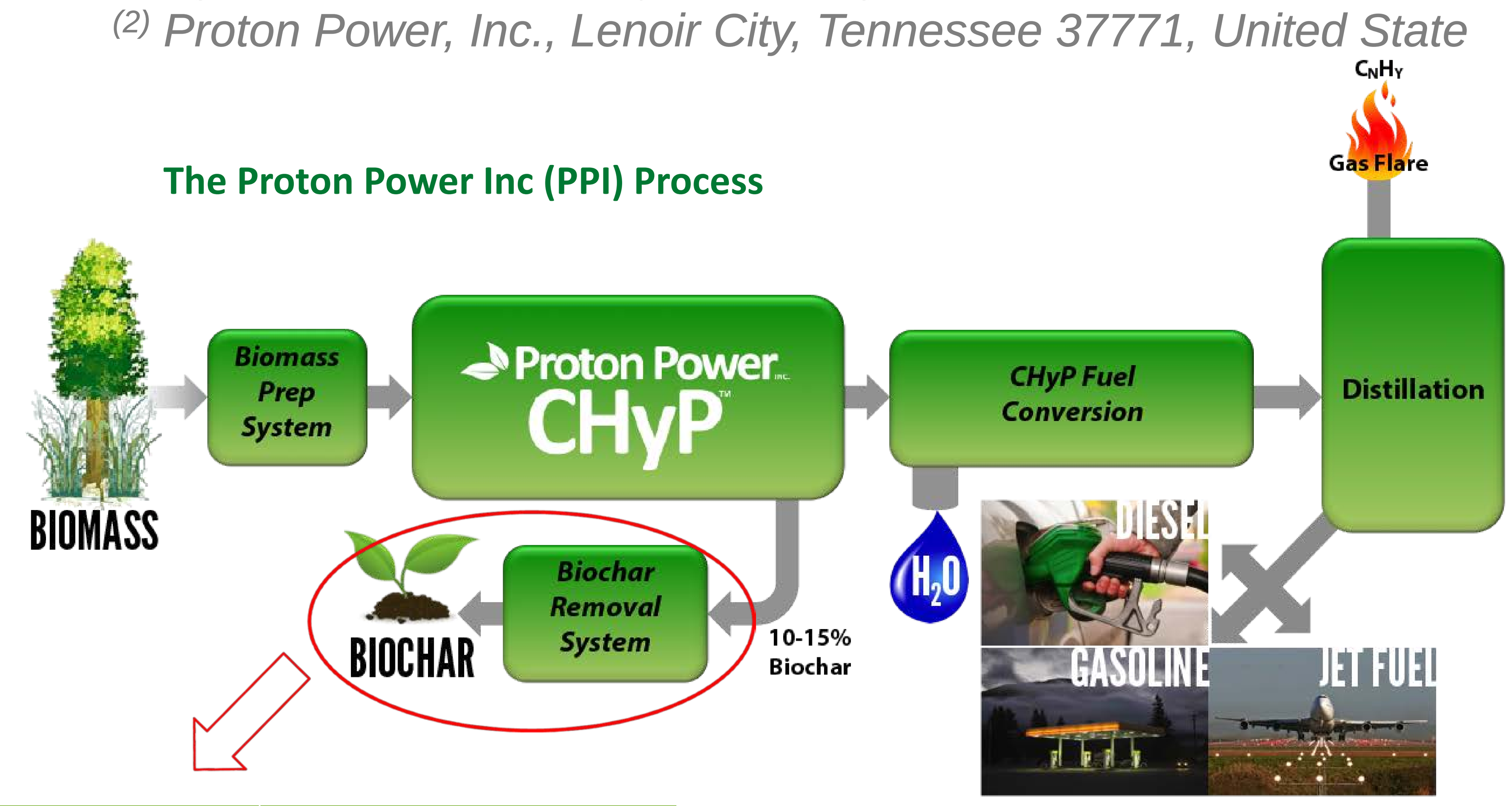
Introduction

High temperature pyrolysis of biomass is a source of synthetic fuel and hydrogen, but also generates large amounts of char.

ORNL is collaborating with Proton Power Inc (PPI) for assessment of the biochar as a potential feedstock for activated carbon production and increase the biochar's economical value. The chars have incipient porosity and low BET surface areas (150 – 300 m^2/g).

Samples provided by PPI were evaluated and processed at ORNL. Samples were physically activated with CO_2 to burn-off levels of up to 45% at either 700 or 800ºC. Characterization of the surfaces properties of the activated samples was carried out using nitrogen adsorption techniques.

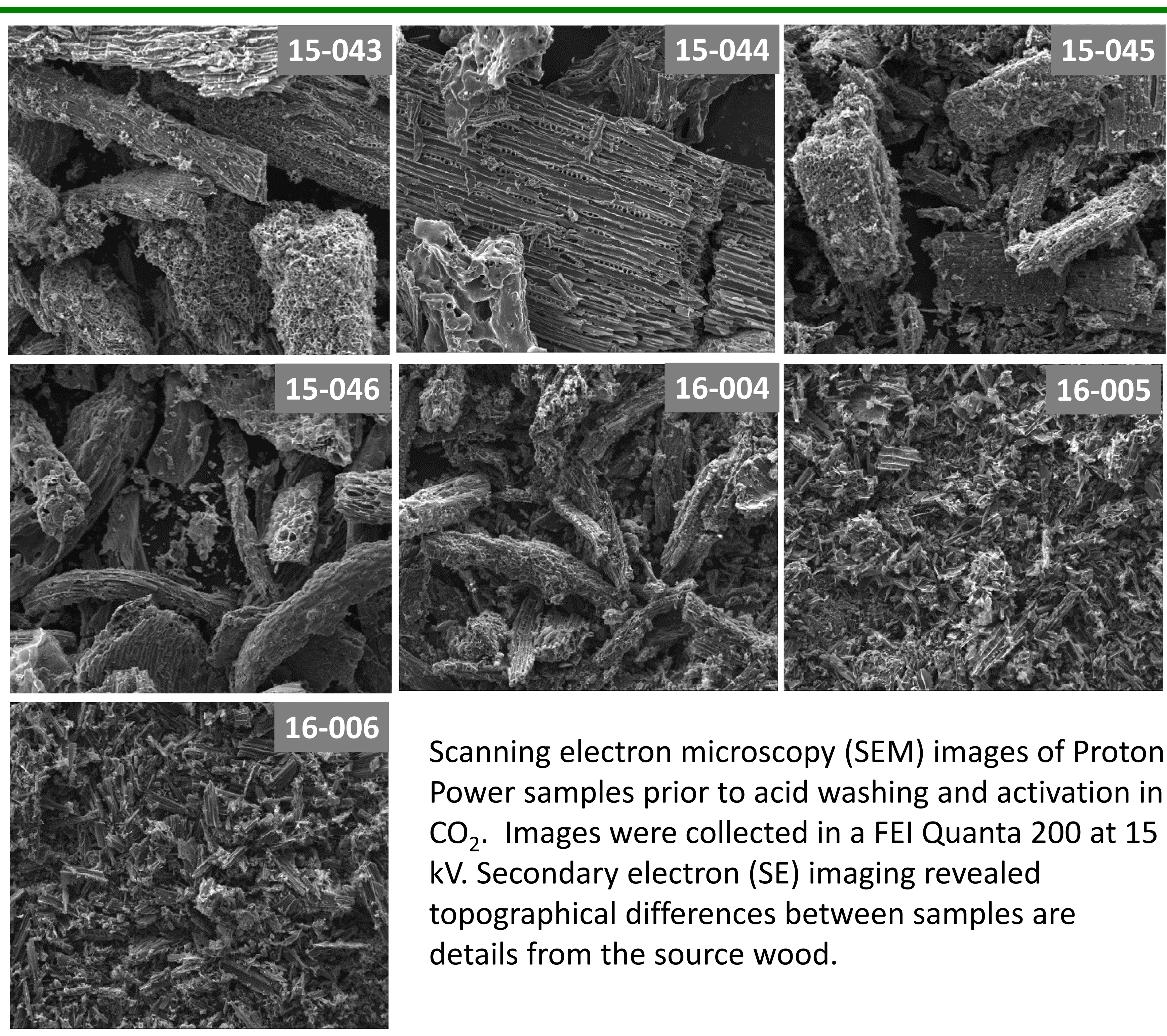
The Proton Power Inc (PPI) Process



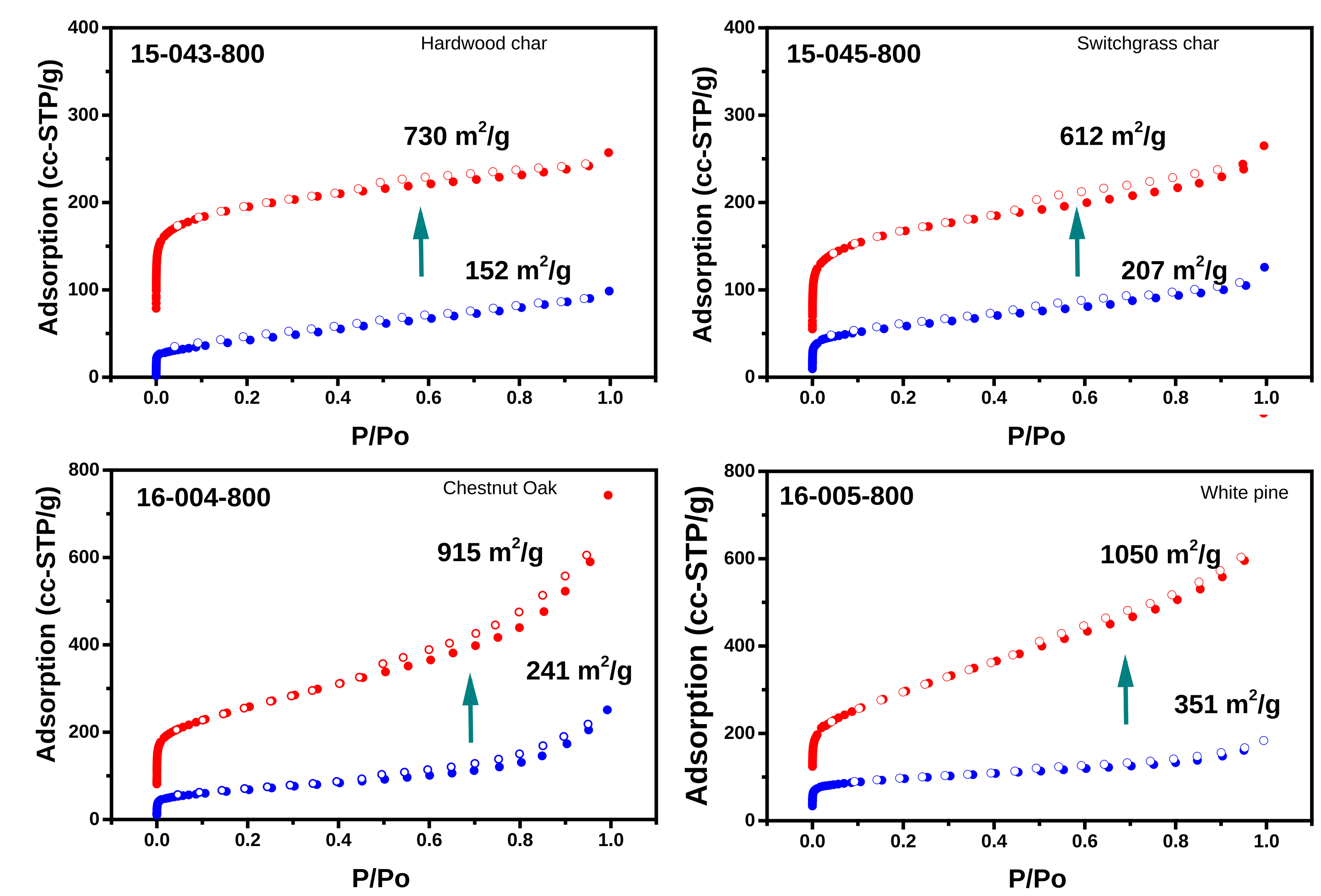
Sample ID	Origin
15-043	PPI Hardwood char
15-044	PPI Redwood char
15-045	PPI Switchgrass char
15-046	PPI Corn Stover char
16-004	PPI Chestnut oak
16-005	PPI White pine
16-006	PPI Yellow poplar

The Proton Power Process

High temperature pyrolysis of cellulosic biomass, releases volatile organic compounds and hydrogen gas. These streams are captured and processed to obtain clean hydrogen gas or synthetic fuels. A co-product of this fuel production is the pyrolyzed biomass, which is often referred to as "pyrogenic carbon" or "biochar". PPI estimates that annual production of five million gallons of synthetic fuel at their demonstration facility in Tennessee, will produce approximately 8,000 tons/yr of black carbon.

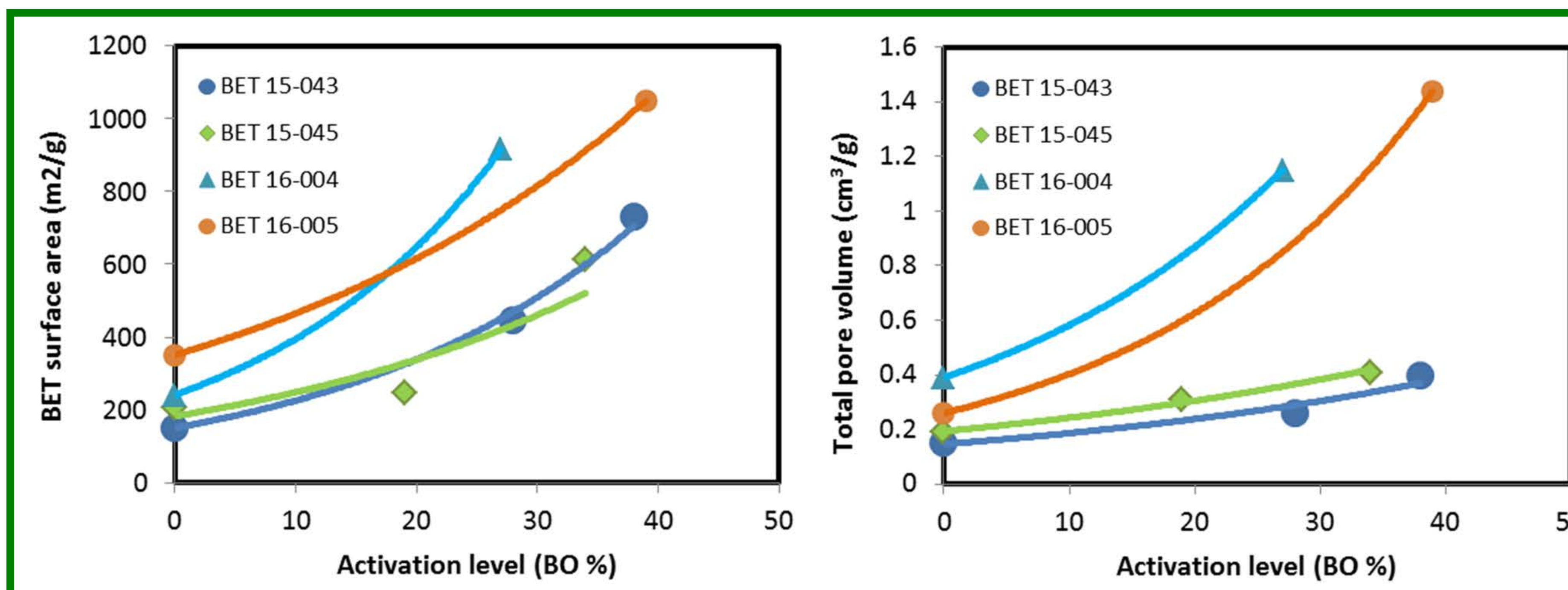


Scanning electron microscopy (SEM) images of Proton Power samples prior to acid washing and activation in CO_2. Images were collected in a FEI Quanta 200 at 15 kV. Secondary electron (SE) imaging revealed topographical differences between samples are details from the source wood.



Nitrogen adsorption isotherms for selected chars in as-received condition (blue) and after physical activation with CO_2 (red). The BET surface areas before and after are shown on each graph.

Sample	Burn Off [%]	S_{BET} [m^2/g]	V_t [cm^3/g]	$V_{micro <20A}$ [cm^3/g]	Source
15-043	0	152	0.15	0.05	Hardwood
15-043-700	28	448	0.26	0.17	
15-043-800	**38**	**730**	**0.40**	**0.27**	
15-044	0	159	0.17	0.04	Redwood
15-044-700	20	354	0.21	0.14	
15-044-800	44	625	0.33	0.24	
15-045	0	207	0.19	0.08	Switchgrass
15-045-700	19	246	0.31	0.08	
15-045-800	**34**	**612**	**0.41**	**0.22**	
15-046	0	333	0.27	0.12	Corn stover
15-046-700	22	516	0.32	0.19	
15-046-800	29	611	0.38	0.22	
16-004	0	241	0.39	0.07	Chestnut oak
16-004-800	**27**	**915**	**1.15**	**0.28**	
16-005	0	351	0.26	0.13	White pine
16-005-800	**39**	**1050**	**1.44**	**0.33**	
16-006	0	529	0.4	0.19	Yellow poplar
16-006-800	47	686	0.51	0.25	



Evolution of BET surface area and of total pore volumes for selected chars as a function of burn-off level during physical activation with CO_2.

Conclusions/Future Work

This work demonstrated that the char co-products can be easily converted into a porous (activated) carbon. After physical activation with CO_2 and burn-off levels between 30 and 40 %, some of the samples were converted into activated carbons with BET surface area of 800 – 1100 m^2/g, total pore volumes of 1.1 – 1.4 cm^3/g, and micropores / mesopores ratios between 3:1 and 1:3.

With these properties the activated carbons derived from the biochar can potentially be used for municipal water treatment and/or for removing heavy metals from various industrial water streams.

We have demonstrated the prospect of converting a carbon char co-product into a higher value carbon material. We have shown that local biomass resources can be used to generate this high value carbon material. This knowledge can help communities generate valuable carbon locally with available resources which will support creating new jobs and expanding the local economy.

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