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Assessment of Greener Cement by employing thermally treated sugarcane straw ashes

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HIGHLIGHTS

- Sugarcane straw ashes (SCSA) are suitable as pozzolanic material for cement uses.
- A Rietveld refinement method using C-S-H phase was successfully done.
- The cement setting time was delayed by SCSA burned at 700 °C.
- SCSA burned at different temperatures shows pores with different size and form.
- Replace 20% of clinker by SCSA is a good option to recover agroindustrial wastes.

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ABSTRACT

Sustainable development has been growing concern worldwide, with special emphasis to its effects on climate change. An important action to reduce the environmental damage is the decrease of cement use. In this study the pozzolanicity of Sugarcane Straw Ashes (SCSA), thermal treated, at different curing times was investigated. Synchrotron X-ray Powder Diffraction measurements allowed the quantification of several phases of the cement pasts through Rietveld analysis. The properties of cement paste are directly related to the concentrations of Alite, Belite, Portlandite, Brownmilite and amorphous phases. Tomography technique was also used to study the differences amongst the pore structures according to type of ash used. The SCSA substitution of 20% (weight) in Ordinary Portland Cement (OPC) shows to be a good option to recover the agroindustrial wastes.

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1. Introduction

The cement industry is facing unprecedented challenges related to depleting of fossil fuels and growing environmental concerns linked to climate change [1]. The most widely used form of that material today – Portland cement – is made by heating limestone and clay in kilns in a process that sends nearly a tonne of CO_2 skywards for a similar amount of final product. The manufacture of Portland cement accounts for roughly 5% of all man-made greenhouse gas emissions [2].

Nonetheless, the prospect of carbon taxes and cap-and-trade markets has led several industry groups to embrace green or sustainable cement alternatives.

A remarkable contribution towards a sustainable development of the cement and concrete industries can be achieved by a partial replacement of cement with pozzolans, a broad class of siliceous materials that reacts chemically with calcium hydroxide in the presence of water at ordinary temperature to form compounds with cementitious properties.

The general definition of a pozzolans includes a large number of materials which vary widely in terms of origin, composition and properties. Major sources of natural and artificial pozzolans include volcanic mineral deposits, fired and crushed clay, and furnace slag from industrial processes such manufacturing steel

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[3]. The benefits of using pozzolanic material as additive or partial substitute to cement are basically threefold: first, the process emits less CO_2 and requires less energy, second, the economic gain obtained by replacing a substantial part of the cement by cheap and abundant materials and, third, to offer the opportunity to create value by converting industrial by products into durable construction materials [4–8].

Sugarcane straw ashes (SCSA) are a by-product of sugarcane which can be used as a pozzolan to substitute the cement [4,6,7]. In Brazil, millions of tons of sugarcane are produced every year. Each ton generates about 20 kg of ash, becoming an environment liability that this industry has to deal it. Currently, although is not appropriate, the ashes are being used as fertilizer.

Significant progress in green cement technology has been made over the last years [4–10]. However, further improvements in the cement formulation and production are contingent on deeper understanding of its structural and chemical features as well as its pozzolanic activity [11–13]. Here, we investigate the behavior of green cements during the hydration processes by synchrotron X-ray diffraction and computed microtomography, providing original and valuable information that is not accessible by other techniques. We report the impact of the calcining temperature on sugarcane straw ashes (SCSA) which were used as partial substitute to Portland cement, demonstrating the potentially of this approach in answering questions about its structure and composition and the reactions that ensue when it is mixed with water.

Table 1
Chemical composition and LOI of SCSAs at various conditions.

T_{calc} [°C]	LOI	Composition [%]										
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	SO_3	P_2O_5	Cl	K_2O
600	2.97	64.4	9.29	3.93	1.19	3.83	2.54	0.07	3.29	2.00	0.68	5.44
700	2.08	61.0	9.2	4.99	1.29	4.40	2.79	0.15	3.85	2.29	0.55	6.98
800	1.74	62.3	8.55	4.57	1.14	5.24	2.7	0.14	4.3	2.2	0.17	6.42
900	0.89	64.7	9.62	4.54	1.21	4.11	2.79	0.16	2.64	2.5	0.06	5.37

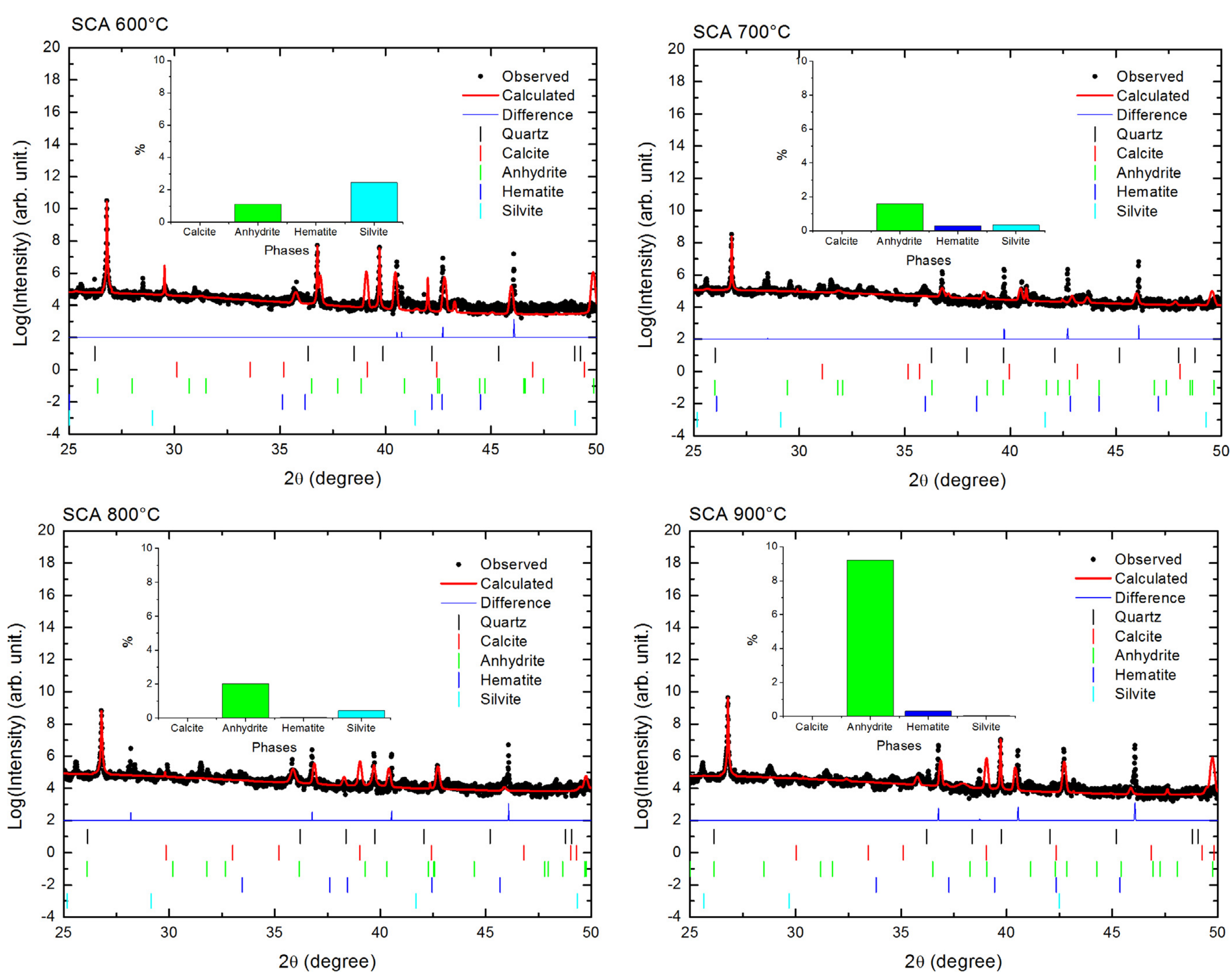

Fig. 1. XRD pattern of the SCSA-600 (a), SCSA-700 (b), SCSA-800 (c) and SCSA-900 (d).

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