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Improving cracking and drying shrinkage properties of cement mortar by adding chemically treated luffa fibres

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HIGHLIGHTS

- The relationship between different treatment conditions and crystallinity index was discussed.
- Microstructure of luffa fibres under different treated conditions were measured.
- The relation between luffa fibre content and cracking resistance and dry-shrinkage was described.
- Treated luffa fibres had a stronger effect on the early cracking than untreated luffa fibres.

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ABSTRACT

This paper presents a study on the effect of luffa fibres by different chemical treatments of luffa fibres on cracking resistance and drying shrinkage of cement mortar. This research is aimed at using natural vegetable fibres to improve the performance of cementitious materials for sustainable construction. XRD was carried out to characterize the crystallinity of treated luffa fibres. By changing the chemical treatment parameters, the relationship between different treatment conditions and crystallinity index was investigated. SEM was used to characterize the microstructure of luffa fibres. The early cracking and drying shrinkage of cement mortar with the addition of treated luffa fibres were experimentally studied. The results revealed that treated luffa fibres had a stronger effect on the early cracking than untreated luffa fibres, while the effect on the drying shrinkage of cement mortar was comparable between treated and untreated luffa fibres.

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1. Introduction

Luffa sponges have a netting-like fibrous vascular system and are relatively stable in their intended lifetime but would biodegradable after disposal in composting conditions. Luffa fibres with hierarchical cellular microstructures have attracted considerable attention due to their outstanding properties such as biodegradability, low cost, light-weight and renewability [1,2]. This is also potential to exploit the remarkable cellular microstructures of luffa fibres to achieve multi-functions as vibration and shock isolation, catalyst carriers, and thermal insulation, etc.

In our previous research, we discovered that the luffa sponge materials exhibited outstanding stiffness, strength and energy absorption capacities which are comparable to those of some metallic cellular materials in a similar density range [3–5]. Only a limited amount of research has been conducted on the luffa sponge. Most research focused on using luffa sponge as a source of bio-fibres and bio-composites, such as for packaging materials, water absorption, and waste water treatment [6–8]. The luffa fibres were also used as the reinforcement fibre for other materials [9]. So far, there has been little research reported on using luffa fibres to improve the cracking resistance of cement mortar.

It is generally known that the evolution remarkable of micro-cracks will significantly affect the strength of cement mortar. In previously published work, some synthetic fibres like EVA, polyvinyl alcohol (PVA) and polypropylene have been used to produce fibre–cement products using the Hatscheck process [10,11]. However, most of the man-made materials are not environmental-friendly and little attention has been paid on their sustainability [12,13]. The importance of luffa fibres is growing as we search for sustainable solutions using natural or unexploited fibres. According to the previous report, pre-treatment of luffa fibres have an effect on the structural properties [14].

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Table 1
Physical and mechanical properties of cement.

Strength grade	Fineness (%)	Water demands of standard consistence (%)	Setting time (min)		Flexural strength (MPa)		Compressive strength (MPa)	
			Initial	Final	3d	28d	3d	28d
42.5	1.95	26.70	160	280	5.5	9.0	23.6	48.8

Table 2
Physical properties of natural sand.

Fineness modulus	Compact volume density (kg/m^3)	Packing density (kg/m^3)	Water content (%)	The biggest size (mm)	Silt content (%)
2.46	1700	1383	2	2.5	1.13

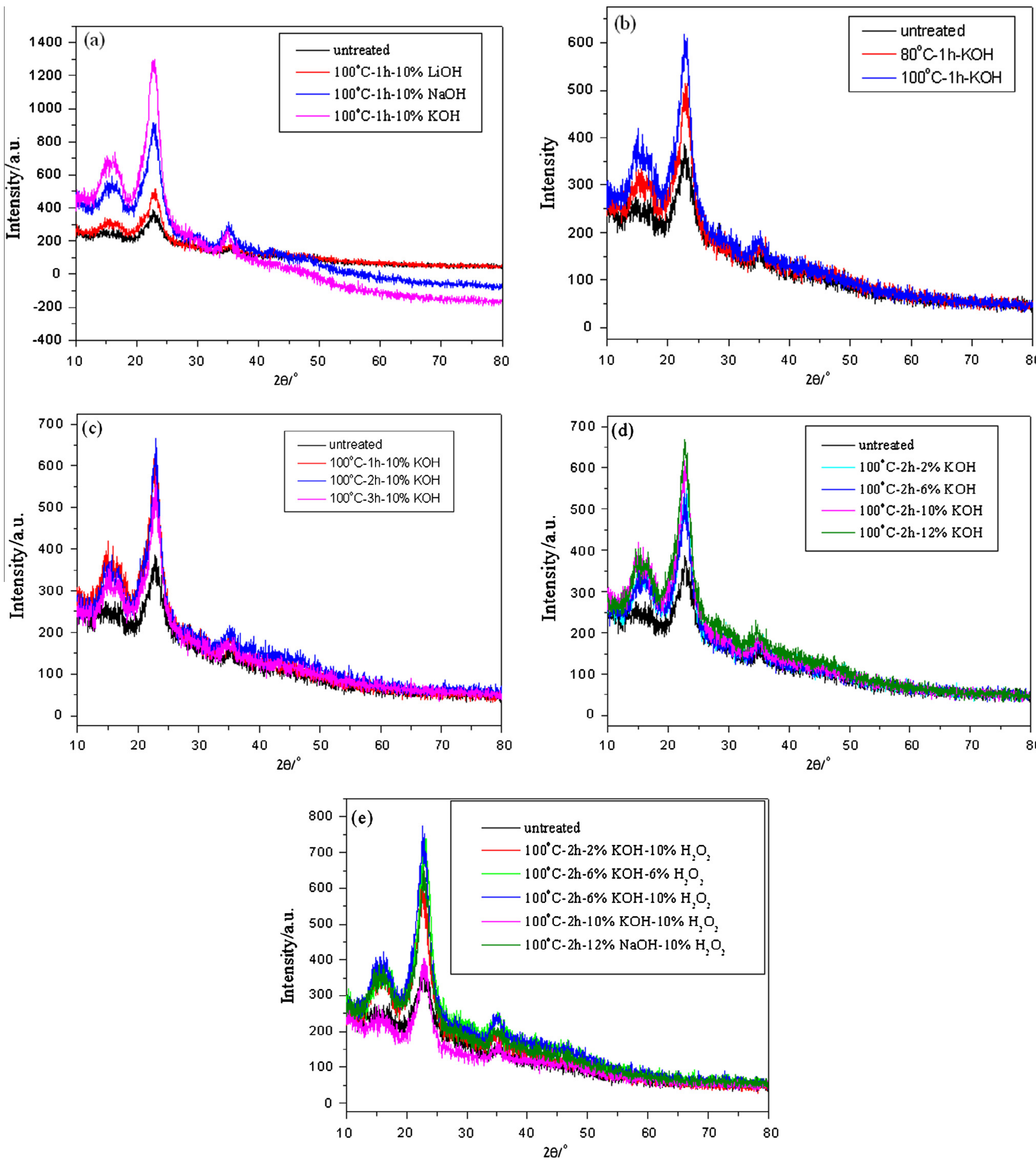

Fig. 1. XRD patterns of products under different treatment conditions.

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