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Pyrolysis mechanisms of typical seaweed polysaccharides

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ABSTRACT

The pyrolysis mechanisms of typical seaweed polysaccharides were investigated using TG-MS and Py-GC/MS. It was found that *Enteromorpha polysaccharides* (EN) was mainly composed of glucan, xylan and glucuronide-sulfate-rhamnose, while *Sargassum fusiforme* (SA) mainly consisted of uronic acid, sulfate group-fucose and polysaccharide galactose. Because of the component differences, it was found that the content of oxygen-containing functional groups and inorganic oxides varies. Meanwhile, three types of sulfur-containing functional groups (sulfonyl groups, sulphates, sulfate) were observed in seaweed polysaccharide. During the pyrolysis process, SO_2 was generated because of the cleavage of sulfuric acid group in 4-*O*-glucuronide-2 sulfate-L-rhamnose. The generation of CO_2 was due to the decarboxylation of organic matter. Besides, Py-GC/MS analysis indicated that the main pyrolysis products of EN polysaccharides were furans. The pyrolysis products of SA polysaccharides were mainly ester substances. Thus, the pyrolysis mechanisms as well as the generation pathways of main products of polysaccharides pyrolysis, were revealed.

1. Introduction

In the context of global energy crisis, biomass energy is receiving more attention worldwide because of its advantages such as renewability, being carbon neutral, etc. Seaweed is an abundant biomass with high photosynthetic efficiency, high reproduction rate and strong adaptation ability. It is also small in size, easy to cultivate and doesn't take up any arable land. Therefore, it is regarded as a very promising resource. The transformation and utilization of biomass mainly include: direct combustion, hydrothermal liquefaction, pyrolysis, fermentation, etc. Due to the simplicity of the process and low production costs, pyrolysis has received more and more attention [1,2].

Many researchers worldwide have increased their efforts in pyrolysis research of macro algae [3,4]. Bea et al. analyzed the feasibility of extracting bio-oil from algae through pyrolysis [5]. Wang et al. studied the pyrolytic and dynamic characteristics of seaweed using TGA [6–8]. Budarin extracted bio-oil from macroalgae using microwave-mediated pyrolysis, the extracted bio-oil contained aromatic hydrocarbons and other high-valued chemical materials [9].

Currently, seaweed biomass pyrolysis and biofuel extraction are under further investigation by researchers worldwide. However, the chemical components of seaweed bio-oil are complex, including acids, aldehydes, ketones, alcohols, esters, furans, phenols and other compounds. As a chemical raw material and bio-crude oil, seaweed bio-oil can be upgraded. However, only few literatures have deeply explored the pathway of algae pyrolysis. They mainly studied pyrolysis products and kinetics of pyrolysis of algae. Therefore, a clear understanding of the formation mechanisms of the pyrolytic products will help to determine the appropriate reaction conditions, improve the quality of bio-oil and increase the yield of the target products. Therefore, in order to produce a high-quality bio-oil, the pyrolysis mechanisms and characteristics of seaweed needed to be further and properly investigated.

The main organic components of seaweed are polysaccharides, proteins and lipids, and the relative contents of these three constituents of EN are 36.84%, 22.10% and 1.18%, respectively [10]. Some researchers reported that the thermal decomposition of the main components of seaweed took place via complex mechanisms [11–13]. Despite the fact that some scholars have begun to investigate the pyrolysis mechanisms of different components of seaweed [14–16], most of the studies mainly reported the weight loss

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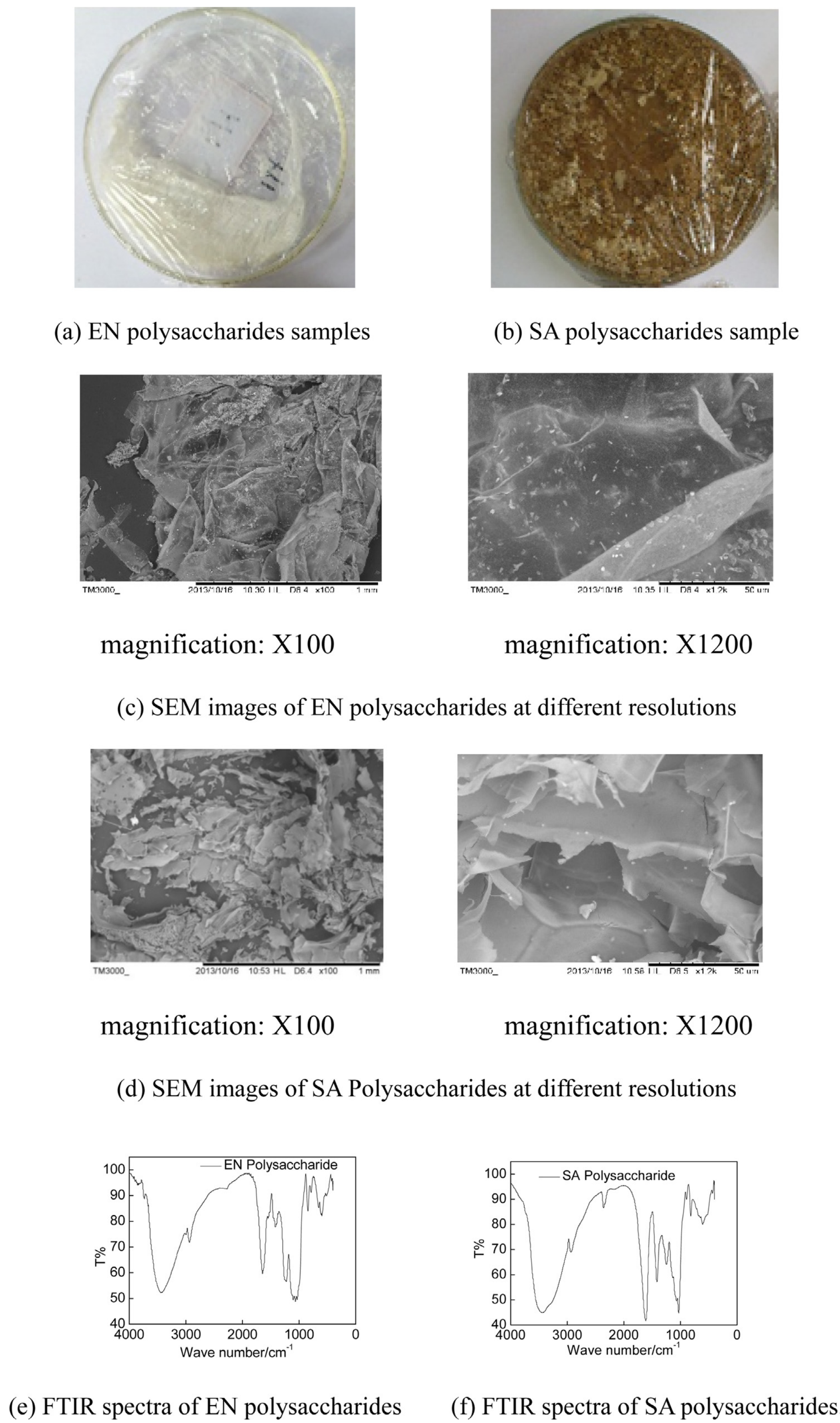

Fig. 1. SEM images and FTIR spectra of EN polysaccharides and SA polysaccharides.
(a) EN polysaccharides samples.
(b) SA polysaccharides sample.
(c) SEM images of EN Polysaccharides at different resolutions.
(d) SEM images of SA Polysaccharides at different resolutions.
(e) FTIR spectra of EN Polysaccharides.
(f) FTIR spectra of SA Polysaccharides.