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Proximate analysis of sawdust using Near Infrared Spectroscopy and locally weighted partial least squares

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Abstract

In recently years, biomass as a renewable and widely available source of energy has increasingly been used in power generation industry and the concept of bio-power is widely accepted. However, conventional methods for proximate analysis are time consuming and can only be performed in laboratory. In this paper, 110 biomass samples are collected and near infrared spectroscopy (NIRS) technology is applied to predict proximate analysis of samples. The data show that NIRS combined with the locally weighted partial least squares (LW-PLS) obtained better prediction results comparing to conventional methods like principal component regression (PCR) and partial least squares (PLS).

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Keywords: NIRS, proximate analysis, sawdust, LW-PLS;

Nomenclature

X	NIRS spectra matrix ($n \times p$)
Y	Proximate analysis matrix ($n \times m$)
n	The number of samples
m	The number of biomass contents to be measured
p	The number of spectra signals

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U	Characteristic factor matrix ($n\times d$)
Q	Load matrix($d\times m$)
T	Absorbance characteristics factor matrix ($n\times d$)
P	Absorbance loading matrix ($d\times p$)
F	Residual matrix ($n\times m$)
E	Residual matrix ($n\times p$)
$\mathbf{E}_d$	Error matrix
B	d-dimensional diagonal regression coefficient matrix.
x_q	Input vector
x_i	The i-th training sample
w_i	Weight of the i-th training sample
W	Diagonal weight matrix
m	Weight parameter
ρ	Balance factor B

1. Introduction

The rising price of fossil fuel and the environmental concern encourage the use of biomass as energy sources. Biomass energy has received more and more attention and been regarded to be one of the most prospective source of energy considering its renewable nature, zero net carbon emission and wide availability. In recent years, power industry has paid great attention to development and utilization of biomass resources; the concept of bio-power is now widely accepted. Comparing to traditional fossil fuel like coal, biomass is clean and reproducible. The combustion efficiency of biomass in power generation plants can be up to 45%, comparing with 30-34% of coal. In developed countries such as northern Europe and US, abundant resources and favorable policies have enabled bio-power to expand quickly. In 2005, more than 7% of total investment in renewable energy industry has gone to bio-power. Since then, this number is growing fast. It is estimated that 10-20% of primary energy supply will be provided by biomass by 2050 [1].

The main biomass resources include wood wastes, animal manure, agricultural residues, dedicated energy crops etc. Among them the lignocellulosic biomass plays the dominant role. Currently, there are more than 300 power plants based on lignocellulosic biomass energy in Denmark, Sweden, Finland and other European countries [2].

Before biomass is fed into the power generation boiler, proximate analysis is generally performed. The purpose of proximate analysis is to determine the content of moisture, volatiles, fixed carbon and ash of biomass. The volatiles and fixed carbon of biomass are combustible matter; the moisture and ash of biomass are non-combustible parts [3-4]. It is not only an important indicator to determine the biomass power generation methods, but also an important factor to reflect fuel properties of the material [5-6]. However, conventional method of proximate analysis requires complex and multi-step laboratory analysis, which is time-consuming and requires excellent operation skills [7-10]. Alternatively, as a fast and non-