Determination of the sucrose concentration in process streams of sugarcane bioethanol industry by an optical fiber sensor using artificial neural network processing

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The improvement of the sucrose concentration monitoring in the sugarcane bioethanol industry is an important development in order to enhance the productivity and prevent processing losses. In this research, the measurement of the sugar content in process streams by a Fresnel-based optical fiber sensor is proposed. Light emitted by a laser source is guided through a single-mode fiber, as its end face is placed directly on the liquid sample and actuates as the sensor probe. Because of refractive index difference between the fiber core and the sample, part of the light is reflected on the fiber-liquid interface and is measured by a photodetector. Then, the concentration is calculated as a function of the reflected light intensity and the sample temperature by using an artificial neural network (ANN) model. Initially, the ANN was trained and tested for the measurement of sucrose-water solutions prepared in laboratory and subjected to different temperatures. Subsequently, the network was validated by testing the sensor with samples collected from the plant at room temperature. The preliminary test of pure sucrose-water solutions yielded to a measurement error of less than 0.4 wt%, indicating that the network was successfully modeled. Furthermore, the analysis of the process streams revealed sucrose concentrations of 26.5, 30.2 and 6.7 wt% for the clarified juice, sterilized juice and fermentation vat samples, respectively, which are in good agreement with the correct values. The difference between nominal and calculated values can be explained because of the chemical composition of process streams, with the presence of other compounds than sucrose and water, such as small concentrations of ethanol, fructose, glucose and minerals, which could affect the refractive index of the sample. The implementation of ANN processing in conjugation with the fiber sensor provided reliable results, with perspectives of effective application on several stages of the plant facility.