Comparative Study of Portable and Tabletop Spectrometers for Monitoring of Bioprocesses

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Highlights

- Portable spectrometers under $2000 are a good cost-effective alternative for the analysis of samples using visible and NIR spectroscopy.
- Atline spectroscopy was performed to estimate biomass concentration.
- The optical spectrometer from Ossila showed reasonable accuracy when compared with a standard UV-Vis Spectrophotometer.

1. Introduction

Spectrometers are widely used for the spectral characterization of components and are also employed for on-line monitoring of industrial processes. Hence, spectroscopy is an essential part of the academic curriculum for any science or engineering discipline. Portable and hand-held spectrometers are gaining traction and can be a good low-cost option in laboratories for spectral analysis [1]. Ossila, Spectral engines, and Texas Instruments have spectrometers operating in the visible-NIR region that are under $2000. The feasibility of such portable spectrometers replacing the expensive and bulky spectrometers was studied using the Optical spectrometer (320 nm -1050 nm) from Ossila.

The aim of the experiment carried out was an estimation of biomass concentration in the fermentation process of *Lactococcus lactis* [2]. Samples were taken every one hour and absorbance readings were simultaneously taken with both Ossila spectrometer and JASCO's UV-Vis Spectrophotometer. The corresponding concentrations were estimated using a calibration model developed for the instruments.

2. Methods

The samples from the fed-batch fermentation experiments carried out in a 2.4 L bioreactor were collected hourly and pelletized. These pellets were resuspended in Sodium chloride solution to study the optical density at 600nm. All the sample absorbances were measured using JASCO UV-Vis Spectrophotometer (V-550) and Ossila's Optical Spectrometer. The setup to measure the absorbance is shown in Figure 1 below.

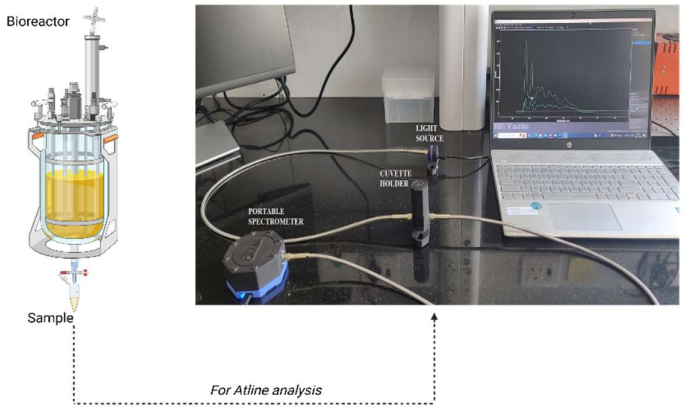

Figure 1. Measurement setup using a portable optical spectrometer

The sample was placed in the cuvette holder illuminated by the light source. The other end of the cuvette holder was connected to the spectrometer using optical fibers. The spectrometer was connected to the laptop via USB.

3. Results and discussion

The results for two sets of experiments conducted are shown below in Figures 2 and 3. The absorbance plots show the values recorded at 600 nm for the biomass samples. The calibration model (Concentration g/L = 0.35*Absorbance) for the Optical spectrometer was developed with samples of known concentration (0.5 g/L – 1.3 g/L).

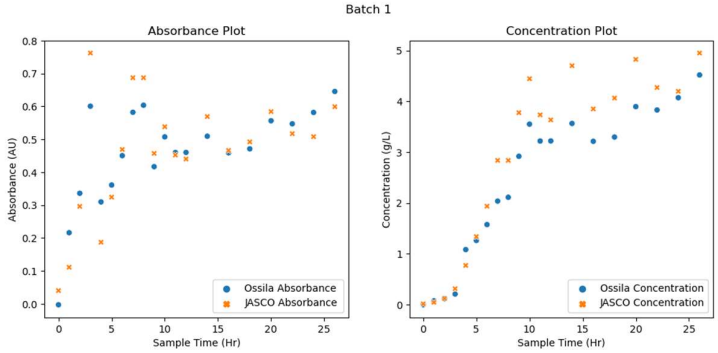

Figure 2. Absorbance and Concentration plots for Batch 1 samples

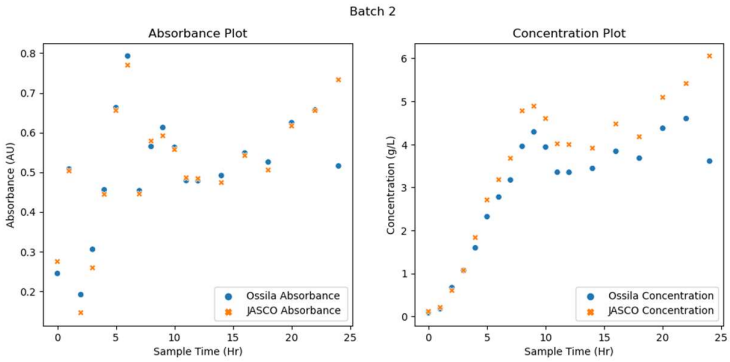

Figure 3. Absorbance and Concentration plots for Batch 2 samples

The Mean Absolute Error Percentage observed in the absorbance values measured using Ossila spectrometer in comparison with the standard spectrophotometer was around 12% for Batch 1 data and 5% for Batch 2 data.

4. Conclusions

The experimental data show that the portable spectrometer can be effectively used to measure spectral characteristics with an acceptable accuracy. The measurement done for the estimation of biomass concentration was Atline. On-line monitoring of the process can also be done with a trans-reflectance dip probe connected to the spectrometer. The price point of these devices enables their easy procurement and can also be used as effective teaching tools for the spectroscopic assessment of different substances or reactions.

References

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[2] Puvendran, K., Jayaraman, G. Enhancement of acetyl-CoA by acetate co-utilization in recombinant Lactococcus lactis cultures enables the production of high molecular weight hyaluronic acid. Appl Microbiol Biotechnol 103, 6989–7001 (2019).

Keywords

Spectrometer, portable, atline spectroscopy