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Automated biochemical analysers and blood coagulation analysers in the era of big data.

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Abstract

The widespread application of big data and artificial intelligence technologies across various industries has had a significant impact on societal production activities. Automated biochemical analysers and automated blood coagulation analysers, as crucial diagnostic tools in the medical field, are also inevitably subject to the influence of this powerful trend. In this field, employing more models, using more algorithms, and analysing more data will bring about more and improved outcomes.

Keywords: Blood coagulation, Biochemical, Clot waveform analysis, Big data.

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About the study

The fundamental principle of measurement in automated biochemical analysers and blood coagulation analysers is the well-known Beer-Lambert law. This law converts the concentration signal of the sample we want to know into a light signal, enabling the determination of concentration signal by measuring the intensity of the light signal. In practical applications, the fundamental principle is manifested in two types of analysis measurement curves: The standard curve and the reaction curve.

The standard curve is obtained by measuring a set of known concentration samples, establishing the relationship between the response signal and the concentration. Typically, the standard curve is a straight or curved line that can be used to determine the concentration of unknown samples based on measured response signals. Therefore, finding a function that more accurately reflects the relationship between the absorbance of the tested substance and its concentration is significant to the measurement process.

Currently, research on standard curve functions is mainly focused on three directions

Expansion and novel models: One of the primary directions in standard curve function research involves expanding and establishing new models. Xianmin *et al.*, [1] introduces a novel model based on the sine function for constructing standard curves. Furthermore, instrument manufacturers have proposed models based on hyperbolic functions, thereby broadening the range of options for calibration function models.

Model improvement: The second direction pertains to improving existing models. As outlined in Guigen *et al.*, [2], efforts have been made to enhance the most popular spline function model in use today.

Comparative analysis and practical application: The third dimension of research explores comparative studies of different standard curve models and their practical application in various scenarios. Often, troubleshooting in actual test results primarily focuses on reagents, while insufficient attention is given to the research on the standard curve itself. Gottschalk *et al.*, [3], highlights the need to investigate the distinct characteristics of various models and their suitability for specific applications. To determine the most appropriate standard curve function model in practical applications, comprehensive comparative studies are required.

Additionally, the concentration range of the standard curve is limited, leading to the problem that samples with concentrations exceeding this range require further processing, resulting in decreased efficiency. Is it possible to increase calibration points to expand the range of analytical measurements, introduce more models, and mine more data to enhance the accuracy of analytical results? The era of big data offers this possibility. Big data technology can also help select the function model with the smallest residuals among various historical calibration function models, quickly obtaining the optimal standard curve.

The reaction curve is obtained by measuring the response signals of samples at different time points and establishing the functional relationship between response signals and time. In the era of big data technology, the frequency of data acquisition during the reaction process can be significantly increased, allowing for a more accurate depiction of the reaction process. Meanwhile, this creates favourable conditions for mathematical processing of the curves and enhances system stability and reliability. In Braun PJ *et al.*, [4] Clot Waveform Analysis (CWA) for reaction curves has been proposed, and it has been linked to specific disease patterns. This demonstrates that reaction curves contain latent information that is waiting to be further explored by researchers.

Historically, the presence of HOOK effect in reaction curves has plagued biochemical analysers and blood coagulation analysers, causing false negatives and being a significant concern for clinical laboratories. Current methods involve identifying the existence of HOOK effect by analysing the first derivative of the reaction curve at different time intervals and using dilution techniques to determine the result. The era of big data provides the potential for more in-depth analysis of the characteristics of reaction curves to extract more relevant information and address hook effect more conveniently.

Furthermore, big data technology makes precise measurement of concentration by multiple variables possible. In essence, standard curves and reaction curves describe the same object. Given this, we consider there should be some connection between them as the below

$$\frac{dA}{dt}=\frac{dA}{dC}\times\frac{dC}{dt}$$

Where $\frac{dA}{dt}$ is the rate of change of the reaction curve and $\frac{dA}{dC}$ is the rate of change of the standard curve, $\frac{dC}{dt}$ is the rate of change of concentration with respect to time, which is also known as reaction rate.

From the above differential equation, we have established a connection between the reaction curve and the standard curve. In addition, the well-known Michaelis-Menten equation has determined the relationship between reaction velocity and substrate concentration in enzyme reactions. Therefore, under certain conditions, there is a relationship between the Beer-Lambert law and the Michaelis-Menten equation. Accordingly, in the first-order reaction region, when the reaction velocity is linear, the rate of change of the reaction curve is also linear. Based on the above, we can achieve precise measurement of concentration through comprehensive analysis with multiple variables, dimensions, and models, all of which require the support of big data technology.

Conclusion

In summary, the technologies of artificial intelligence and big data have a profound impact on automated biochemical analysers and blood coagulation analysers. In these fields, keeping up with the trends of the era involves designing more models and adopting more algorithms for the analysis of vast amounts of data. This allows us to extract more information, ultimately serving the clinical needs of patients more effectively.

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