



Near Infrared Spectroscopy in China

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Abstract. The research and application of near infrared spectroscopy in China has a history of 40 years. This paper mainly introduces the research and application status of near infrared spectroscopy in China, so that the world peers can fully and systematically understand the actual situation of near infrared spectroscopy in China and sense the changes of China from NIR side.

Keywords: China · Review · Chemometrics · Applications · On-line

In the 1980s, near infrared (NIR) spectroscopy was first applied in agriculture in China. In the 1990s, NIR spectroscopy was gradually accepted as a fascinating analytical technology by some analytical scientists and factory managers. In the 2000s, NIR spectroscopy was researched and applied widely in China. In 2009, the China Council of NIR Spectroscopy (CCNIRS) was established, and the Council has played key roles in the Chinese NIR spectroscopy community since. In the past two decades, NIR has developed rapidly in China, mainly in academic research, instrument development, and practical applications in various areas.

Academically, China has published more than 20 monographs on NIR spectroscopy, imaging and their applications. Since the first Chinese Conference on NIR was held in 2006, China has successfully held eight conferences, with more than 200 participants attending each conference. The 3rd and 6th Asian NIR Conference was also held in China in 2010 and 2018. In China, there are about 40 research teams engaged in the research and application of NIR. Every year, they publish about 200 papers in academic journals at home and abroad and apply for about 100 patents (Fig. 1).

In terms of Chemometrics, Academician Yu Ruqin and Professor Liang Yizeng's team have achieved many innovative research results. For example, the variable selection method, competitive adaptive reweighting algorithm (CARS), has attracted the most extensive attention. Professor Shao Xueguang's team has also obtained abundant research results in Aquaphotomics. In addition, there are more than 10 research teams in China that specialize in the study of Chemometrics, and have put forward many innovative algorithms.



Fig. 1. The 6th Chinese conference on near infrared spectroscopy held in Wuhan in march 2016

Chinese instrument manufacturers have developed grating array, Fourier transform and digital micromirror spectrometers with independent intellectual property rights. On this basis, a variety of commercial NIR portable and on-line analyzers applied to the measurement of various liquid and solid samples have been manufactured. Some commercial instruments have exported to Europe, Russia and some countries of Southeast Asia.

China has carried out many practical applications with its own characteristics and achieved considerable economic and social benefits. More than 100 NIR Chinese standard methods has been established, involving grains, chemicals, foods, feeds, textiles, tobaccos and so on (Fig. 2).



Fig. 2. Several Chinese NIR monographs on NIR

In the grain analysis, taking soybeans as an example, NIR has been used to screen high quality seeds rapidly and nondestructively in breeding. Many grain growers also purchase NIR analyzer to guide the planting management of soybeans. In soybean trading, the quality of soybean is predicted by NIR on the spot, and the price is determined according to the protein content. NIR has played an important role in many aspects of edible oil processing. For example, in the leaching process, the oil content of the extracted meal can be determined on-line, and the processing parameters can be adjusted in time to achieve the best leaching effect and significantly improve the yield of oil (Fig. 3).



Fig. 3. Several Chinese standard methods on NIR

In the field of fruit, the portable NIR analyzer is used for fruit tree growth management, providing scientific data for fertilization, irrigation and other cultivation management. In the harvest season, the use of NIR to determine the best harvest time of fruits has become an important means to increase the income for fruit farmers. In fruit screening, Chinese companies have independently developed online sorting equipment suitable for large size fruits such as watermelons, as well as large assembly-line sorting devices for small size fruits such as oranges.

As for tea, NIR provides technical support for geographical indication Protection of Chinese tea, and has been used for quality monitoring in the process of tea processing, such as green tea fixation, oolong tea roasting, black tea fermentation, etc., which can more objectively judge the degree of fermentation, make the fermentation process more scientific and reasonable (Fig. 4).



Fig. 4. On-line near infrared spectroscopy for detecting the quality of tea production process

Traditional Chinese medicine (TCM) is a treasure of the Chinese nation. NIR has been applied to the rapid analysis of the quality and content of specific components of TCM. Many large TCM companies in China have installed on-line NIR analyzer to monitor the extraction, purification, concentration and mixing production process, to achieve the optimal control and ensure the uniform and stable quality of TCM products (Fig. 5).



Fig. 5. On line real-time monitoring of extraction of active components of traditional Chinese medicine by near infrared spectroscopy

China has developed a NIR rapid drug detection system since 2004. For nearly 20 years of application and accumulation, the system has established a complete NIR drug database and identification models of counterfeit drug. At present, there are more than 400 mobile drug detecting vehicles in China, which are used for rapid on-site drug supervision in the countryside, town and urban areas (Fig. 6).



Fig. 6. The drug testing vehicles developed by the national institutes for food and drug control

The ancient Silk Road once made great contributions to the world's economic development and cultural prosperity, and the development of silkworm industry still exerts an important influence. The separation of male and female silkworm pupae is an important

step in the silkworm seed production enterprises. China has developed a high-speed NIR sorting device for male and female silkworm pupae. The device can sort more than 10 silkworm pupae per second with an accuracy rate of 98%.

In China, many famous liquor enterprises use NIR to monitor the fermentation process of fermented grains, selecting and controlling the best fermentation conditions, so as to ensure product quality, increase output and reduce energy consumption at the same time. NIR is also used in the fermentation production process of vinegar, soy sauce and other condiments.

In large scale process industries, such as refineries and petrochemical plants, NIR has become one of the representative technologies of modern intelligent factory. China has established a complete NIR database of crude oil based on thousands of samples, which plays an important role in petroleum exploitation, trade and processing. The combination of the on-line NIR and the advanced process control and optimization system has realized the optimal operation in many Chinese refinery units (Fig. 7).



Fig. 7. On-line near infrared spectroscopy probe for monitoring chemical reaction process

NIR is used by Chinese geologists to quickly identify mineral types in the field and obtain the geographical distribution characteristics of different minerals in a specific area, which can provide a basis for further drilling work, save a lot of exploration costs and improve the efficiency of prospecting.

With the help of big data, Internet of Things and cloud computing technology, Chinese tobacco enterprises have built a NIR big data system platform to achieve the goals of center modeling, resource sharing and intelligent analysis, which can be used for quality control of all aspects of tobacco processing.

China has made a lot of scientific research work in functional near infrared spectroscopy, especially in brain functional imaging technology. Many research results are published in international journals with great influence, and some of them have been applied in psychiatry.

In the future, NIR in China will continue to make substantial progress in the width and depth of spectroscopy theory, instrument development, NIR imaging and their applications.

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References

1. Chu, X.L.: China council of near infrared spectroscopy established in Beijing. *NIR News* **20**, 3–4 (2009)
2. Chu, X.L.: Guest editorial: near infrared spectroscopy in China. *J. Near Infrared Spec.* **23**(5), v–vii (2015)
3. Chu, X.L., Qian, W.: In memory of Dr Lu Wanzhen, champion and pioneer for the adoption of near infrared technologies in China. *J. Near Infrared Spec.* **23**(5), 269 (2015)
4. Chu, X.L., Lu, J.: Research and application status of near infrared technology in China. *NIR news.* **25**(6), 13–15 (2014)
5. Guo, L.H., Yuan, H.F., Chu, X.L.: Report on the sixth asian NIR symposium (ANS2018). *NIR News* **29**(7), 5–7 (2018)
6. Yang, Z.L., Cai, L.W., Han, L.J.: Review of standards of near infrared spectroscopy methods. *J. Near Infrared Spec.* **29**(6), 313–320 (2021)