Issue 1: Welcome! Quick Introduction to Quantitative NMR

Quantitative NMR is a method of quantitative analysis using nuclear magnetic resonance (NMR).

It is called qNMR. Usually, chromatography is regarded as the typical way to perform quantitative analysis. NMR analysis has a quantitative performance in principle, but compared to chromatography, NMR seems to have the image of being “Big, Expensive, Low-sensitivity, and Complicated”

Nevertheless, NMR has been attracting a lot of attention in a variety of fields as the key to improving the reliability of quantitative analysis results. For example, the Japanese Pharmacopoeia has adopted qNMR as a method for purity determination of standard reference materials for chromatography. This improves the reliability of quantitative results of marker compounds in chromatographic analysis.

<What we can do with NMR>

NMR enables the observation of specific nuclei, and we can obtain a variety of information about the analyte. The hydrogen nuclei (1H: proton) in molecules is widely used for qualitative analysis. This is called 1H-NMR. Let’s compare the 1H-NMR spectra of ethanol and methanol. It is possible to obtain a separate signal for each functional group. The positions and shapes of the detected signals are all different. In addition, the intensity of the signals is proportional to the number of protons. As a result, from the NMR spectrum you can identify as well as measure the compounds that you analyze, so it is both qualitative and quantitative analysis.

1H-NMR measurements of sake were performed. The main component of sake is water, and from the spectrum we can see that there is also ethanol. So, what happens when we add a little methanol into the sample? Since the position of the signal detected for methanol is different from the detection position for ethanol, when the methanol is added, we can immediately see that there is something else in the sample. Furthermore, by comparing the areas of the signals for the CH₃ group in the ethanol and methanol, we can determine the ratio of ethanol to methanol that is present.

In this way, it is possible to obtain both intramolecular, and intermolecular quantitative information using NMR.
What we can learn with NMR 1—Identify

$^{1}$H-NMR spectrum: Spectrum of the measured hydrogen nuclei (protons) in the molecule

Ethanol (CH$_3$CH$_2$OH)

- CH$_2$
- CH$_3$
- OH

Methanol (CH$_3$OH)

- CH$_3$
- OH

Different number of signals, as well as different positions and shapes
What we can learn with NMR 2

Add some methanol

Add some methanol

NMR spectrum of sake
(Indicated alcohol content 15 to 16%)
Main components are water and ethanol

NMR spectrum of methanol mixed into the sake

Signal area is proportional to number hydrogen atoms

\[
\frac{S_i}{S_j} = \frac{N_i}{N_j}
\]

S : Integrated signal area
N : Number of hydrogen atoms in the functional group

From the ratio of the areas

\[
\frac{3.00}{0.48} \approx \frac{6}{1}
\]

In other words, the ratio of ethanol to methanol in this solution is 6:1

Main components are water and ethanol

Methanol

CH₃

3.00

CH₃

0.48

H₂O

H₂O

NMR spectrum of sake

(Indicated alcohol content 15 to 16%)

NMR spectrum of methanol mixed into the sake