Evaluating the dispersion of TiO₂ nanoparticles via sp-ICP-MS for sunscreen powder analysis

Introduction
Titanium dioxide (TiO₂) nanoparticles (NPs) are widely used in everyday consumer products such as toothpaste, sunscreens and cosmetics. Because of its high surface area-to-volume ratio, TiO₂ NPs are easy to aggregate due to the high surface activity and changes in surface charge in aqueous solution. Measurement of “real” particle size distribution of the commercial produced in liquid dispersions is not easy and still going on research. Therefore, in this work, we mainly focus on the stability and separation phenomena of TiO₂ NPs of standard material and sunscreens powder in different surfactants, organic or alkaline solution with single particle ICP-MS (sp-ICP-MS).

Experimental

Different diluent
There are 6 different solutions including 1% IPA, 1% FL70, 1% Rutile-TX-100, 1% butanol(NBA), 1% NH4OH, and the mix solution with 1%HNO₃ and Triton X-100 are chosen to be TiO₂ diluents.

Reference Material (RM)
The titanium dioxide (TiO₂) nanoparticles were from US Research Nanomaterials(USRN), Inc. The particle size is 30–50nm provided by USRN.

A silver NP Reference Material (Sigma-Aldrich) with a nominal particle size of 40 nm was used to measure the nebulization efficiency of the ICP-MS.

Sunscreen Powder Sample
There are 5 commercial sunscreen powders bought in Taiwan normal pharmacy. Two kinds of sample preparation methods were tested: (1) microwave digestion and (2) direct dilution.

Sample Preparation
All NP RM and sample solutions were diluted followed by the steps below:

1. Sunscreen powder sample
2. Dilute with DIW to dilution to 100ppt level
3. Sonicate
4. Ms

Instrument and Condition
Agilent 7900 ICP-MS and MassSkinder’s Single Particle Application Module were used for data collecting and analysis. Standard quartz sample introduction systems were used with a 1.5mm injector diameter torch. TiO₂ NPs were measured in no gas mode.

Results and Discussion

TiO₂ RM in different diluents
Different diluents are chosen for the dispersion of TiO₂ NPs. Then dilute the sunscreen sample solution to 100ppt by the new TiO₂ concentration results. The result shows NPs concentration are most within 100–1000 particles/mL and suitable be analyzed by sp-ICP-MS.

Commercial Sunscreen powder Sample: Directly dilution-2
Compared with the powder samples diluted directly with 1% Rutile-TX-100 and Triton X-100-HCl solution, because the particle size is smaller and the particle concentration are more, it shows that the dispersion of the mixture solution on the actual sample is better.

Conclusions
In this work, we have established a test method of spICP-MS for TiO₂ nanoparticles on commercially sunscreen powders, including two methods of microwave digestion and direct dilution, and found suitable diluent for TiO₂ nanoparticle analysis. When the sample was pre-treated by microwave digestion, NH₄OH as a diluent can get a better dispersion of TiO₂ NPs. In the case of the pretreatment using the direct dilution method, compared to the method of directly diluting with Triton X-100, the best result is obtained as the mixture of NH₄OH and Triton X-100 because NH₄OH makes the alkali dilution.

In the future, in the actual sample analysis, ICP-MS can be used for concentration analysis to obtain a more suitable dilution ratio for each sample, making the SOP of TiO₂ NP of spICP-MS more feasible.

References
1. S. Wilbur, M. Yamanaka and S. Sannac, Agilent publication, 2015, 5991-5516EN.