



Application Note AN-RS-036

# Trace Detection of Toxic Dye in Saffron

Protecting consumer safety with MISA

Saffron, a precious spice comprised of dried stigmas from the purple *Crocus sativa* flower, is prized for its many health benefits and for its distinctive color, aroma, and delicate flavor. It is the most expensive spice in the world by weight, due to the labor- and time-intensive process of collecting individual filaments by hand. Saffron quality in the international trade market is certified under ISO 362-1. However, illicit producers sell low-grade or counterfeit saffron to unsuspecting consumers and reap substantial profits. The challenge in authenticating saffron is due to the variety of strategies used to mimic a

pure product, including dyes and the inclusion of flower parts from different species. Successful methods for authentication of saffron typically require complex analytical methodologies in combination with chemometric methods, which does not address the rising demand for cost-effective, on-site analysis and interdiction of counterfeit saffron in the field. SERS (Surface-Enhanced Raman Scattering) detection of a toxic dye (Sudan 1) used to adulterate saffron demonstrates the power of MISA (Metrohm Instant SERS Analyzer) for simple, portable food authentication in this Application Note.

## AUTHENTICATION OF SAFFRON

The most common form of saffron adulteration is the marketing of dyed and dried stamens and stigmas from other flower species to imitate saffron's distinctive visual and sensory properties. In this application, crocin, a carotenoid ester that is primarily responsible for saffron's distinct coloration, is extracted and compared with Sudan 1, an orange-red azo dye and a known carcinogen. Sudan 1 is banned for

use in foods worldwide, yet is frequently used for the illicit coloring of costly spices. In a manner consistent with saffron counterfeiting, non-saffron flower parts are dyed and mixed with authentic saffron for this application. This mixture is extracted and compared to both saffron and Sudan 1 standards to demonstrate the ability of SERS to differentiate these strongly colored compounds.

## MATERIALS AND METHODS

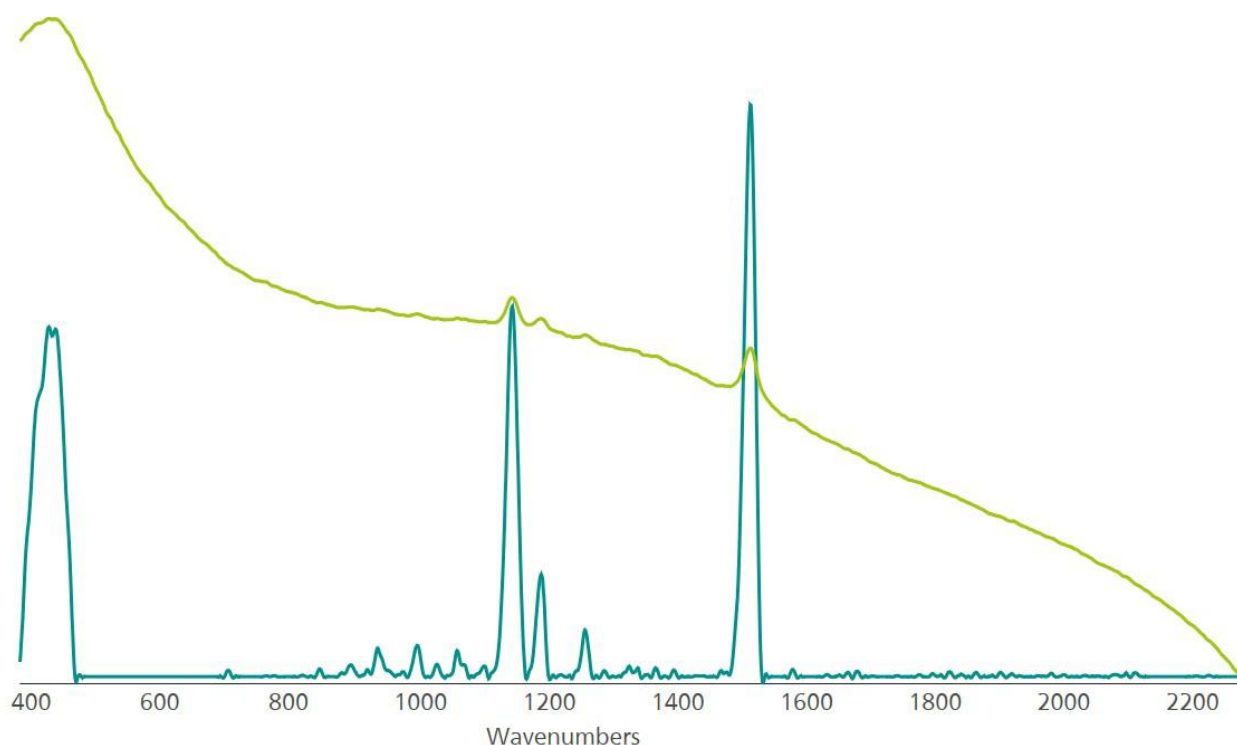
High-quality Negin saffron from Iran was purchased from a commercial supplier. Plant material used for simulating saffron adulteration with biological material consisted of dried stigmas and stamens harvested from flowers purchased at a local grocer. Sudan 1 was sourced from a chemical supplier. Raman spectra were collected directly from purchased saffron, placed in a glass vial, and inserted into the vial holder on MISA. A SERS reference spectrum for saffron required extraction of 100 mg of pure

saffron with 1 mL of methanol, then addition of 100  $\mu$ L each of extract and 0.5 mol/L NaCl to 800  $\mu$ L of Au nanoparticles in a glass vial. The SERS sample was mixed, inserted into the vial holder, and analyzed with the SERS OP on MISA. SERS analysis of saffron adulterated with Sudan 1 consisted of a 1:1 (w/w) mixture of pure saffron and flower parts which had been soaked in a 1 mg/mL solution of Sudan 1 in methanol and dried. Extracts for analysis were prepared as for pure saffron above.

## RESULTS AND DISCUSSION

Saffron can be detected directly with Raman analysis, although authentication would likely require a combination of Raman and chemometrics. This is primarily because highly

colored materials, such as the crocin compounds that lend their color to authentic saffron and the dyes used in counterfeit products, can exhibit fluorescence that overwhelms the Raman signal.

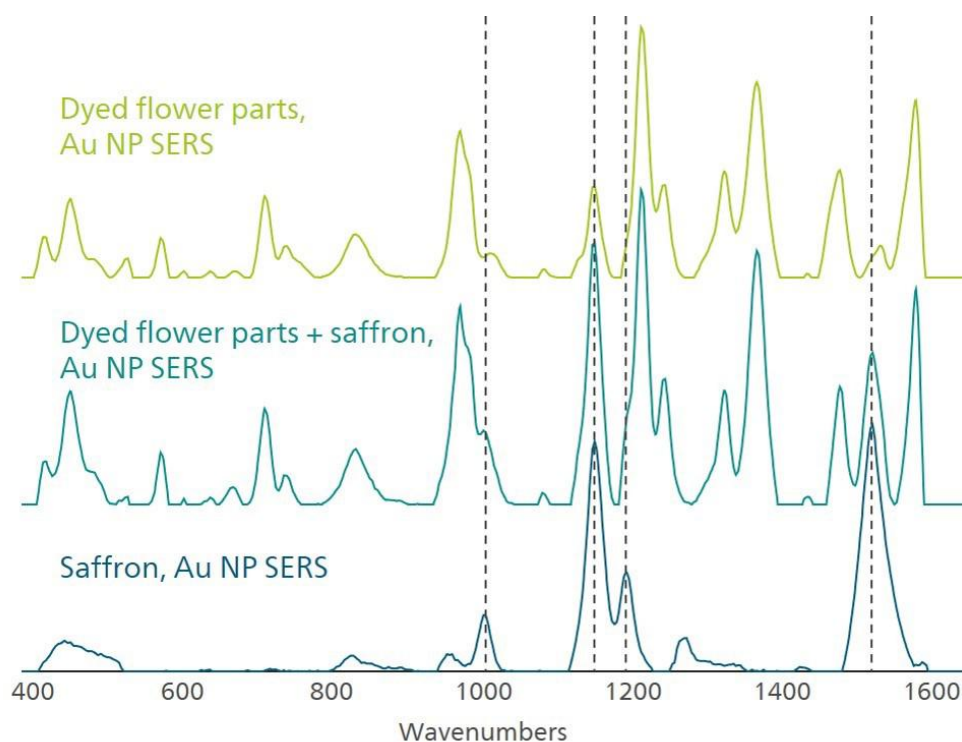


**Figure 1.** Saffron's distinctive Raman spectrum: unaltered (top) and baselined (bottom).

This is demonstrated in **Figure 1**, where the unaltered Raman spectrum of saffron (top) displays the broad, distinctive signal of fluorescence. The baselined spectrum (bottom) contains signature peaks from crocin, but of low intensity. This is a classic example of an application where SERS can more sensitively

evaluate a specific analyte, because fluorescence has less of an influence on the SERS spectrum.

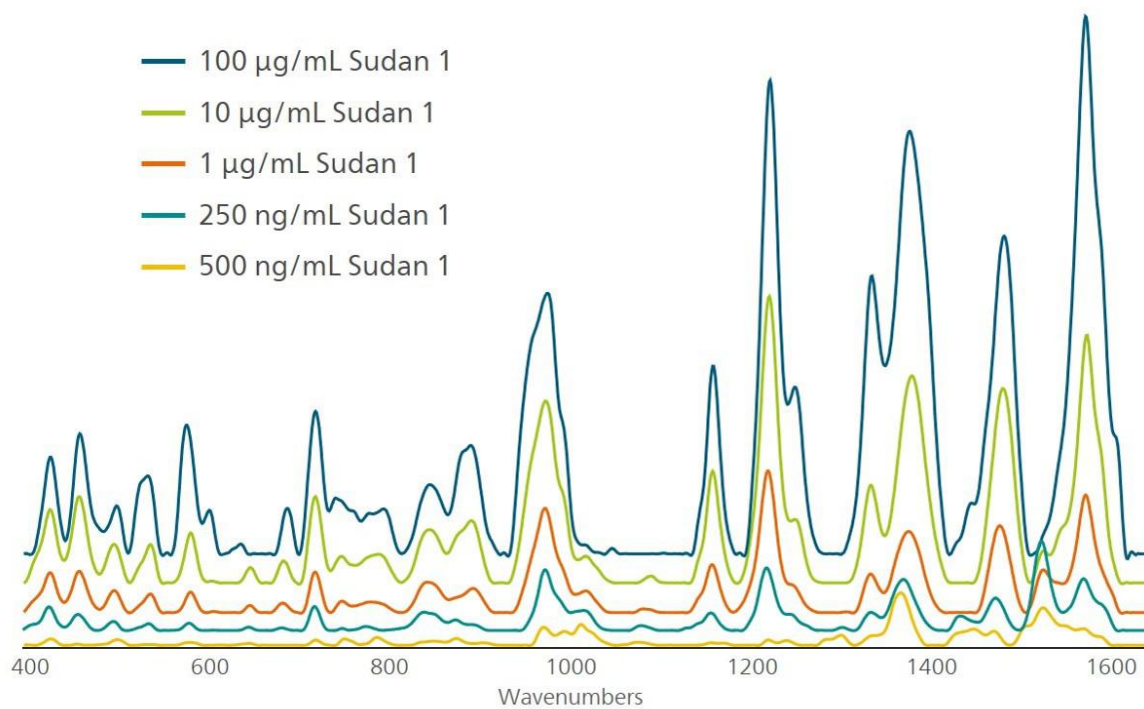
The SERS spectrum for pure saffron provides a useful standard for evaluating the authenticity of saffron, as shown in the bottom spectrum in **Figure 2**.



**Figure 2.** Visual confirmation in the SERS spectra of Sudan 1 (top), Saffron (bottom), and an experimental mixture of both.

The acquired peak profile agrees with reported spectra of crocin extracted from saffron. Sudan 1 at a concentration of 0.01 mg/mL also has a distinct and complex SERS spectrum, as seen in the top spectrum in **Figure 2**. When these distinct spectra are overlaid with the SERS spectrum of a mixture of pure and counterfeit saffron, both pure saffron and Sudan 1 can be distinguished. Finally, detection limits are

important for any trace detection application with SERS. Serial dilutions of 1 mg/mL Sudan 1 dye stock solution in methanol were used to demonstrate detection of Sudan 1 at concentrations as low as 500 ng/mL (**Figure 3**). With this level of sensitivity, the use of virtually any amount of this dye for saffron authentication can be detected with MISA.



**Figure 3.** Concentration profile for Sudan 1, demonstrating MISA's detection capabilities down to 500 ng/mL.



## CONCLUSION

Herein, saffron is authenticated and Sudan 1 is detected by SERS in a demonstration of the growing potential of portable Raman spectroscopy for the frontline defense of food safety and integrity. Given the strong SERS response of chemical structures common to dyes

and artificial food colorants, this application is likely to extend to other coloring agents used to enhance spices and mask inferior product. MISA from Metrohm Raman holds great promise as a versatile tool for protecting food safety.

## CONTACT

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## CONFIGURATION



### MISA Basic

Metrohm Instant SERS Analyzer (MISA) 是一款高性能、便携式分析系,可快速/定非法物、食品添加和微量食品染料。MISA 的特点是配了 Metrohm 独特的道光栅描 (ORS) 技的高效光。其空需求最小和并且池寿命有所延,是或移室用的理想。MISA 提供各 1 激光附件,可活取。分析可通 BlueTooth 或 USB 接行。MISA Basic 套件的作用是用能根据自己的需要整 MISA。是一个入套件,其中包含使用 Metrohm 的米粒溶液行 SERS 分析所需的基本件。

MISA Basic 套件包含了 MISA 器、一个 MISA 小管附件、一个 USB 迷、一个 USB 供元和用来行器的件 MISA Cal。





### MISA Advanced

Metrohm Instant SERS Analyzer (MISA) 是一款高性能、便携式分析系,可快速/定非法物、食品添加和微量食品染料。MISA 的特点是配了 Metrohm 独特的道光栅描 (ORS) 技的高效光。其空需求最小和并且池寿命有所延,是或移室用的理想。MISA 提供各 1 激光附件,可活取。分析可通 BlueTooth 或 USB 接行。MISA Advanced 套件是一个完整套件,其作用是用能用 Metrohms 米粒溶液和 P-SERS 条行 SERS 分析。MISA Advanced 套件包含了一个 MISA 小管附件、一个 P-SERS-附件、一个 ASTM 校正准件、一个 USB 迷、一个 USB 供元和用于行 MISA 器的 MISA Cal 件。随供了一个用来安全保管器和附件的固保箱。



### Misa

与 15 x 26 mm 大小的玻璃品瓶配。Misa 品瓶附件可用于量 Metrohm 的金材 SERS 米粒。搭配 1 激光器使用。