

1 **Rapid detection of synthetic cannabinoids in herbal highs using surface-enhanced Raman**  
2 **scattering produced by gold nanoparticle co-aggregation in a wet system**

3

4 Hiroki Segawa<sup>†</sup>, Takao Fukuoka<sup>‡</sup>, Tamitake Itoh<sup>§</sup>, Yuichi Imai<sup>⊥</sup>, Yuko T. Iwata<sup>†</sup>, Tadashi  
5 Yamamuro<sup>†</sup>, Kenji Kuwayama<sup>†</sup>, Kenji Tsujikawa<sup>†</sup>, Tatsuyuki Kanamori<sup>†</sup> and Hiroyuki Inoue<sup>†</sup>

6

7

8 <sup>†</sup> Third Department of Forensic Science, National Research Institute of Police Science

9 6-3-1, Kashiwanoha, Kashiwa, Chiba 277-0882, Japan

10

11 <sup>‡</sup> Department of Micro Engineering, Kyoto University

12 Kyoto daigaku-Katsura, Nishikyo-ku, Kyoto 615-8540, Japan

13

14 <sup>§</sup> Health Research Institute, National Institute of Advanced Industrial Science and Technology

15 2217-14, Hayashi-cho, Takamatsu, Kagawa 761-0395, Japan

16

17 <sup>⊥</sup> STRAWB Inc.

18 1542-1, Nakahara-cho, Takahashi, Okayama 716-0045, Japan

19

20

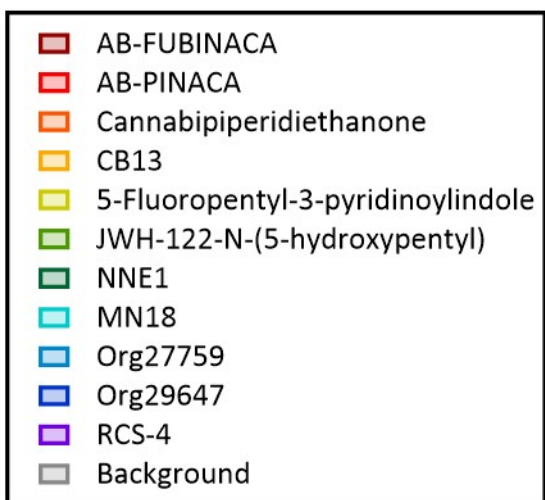
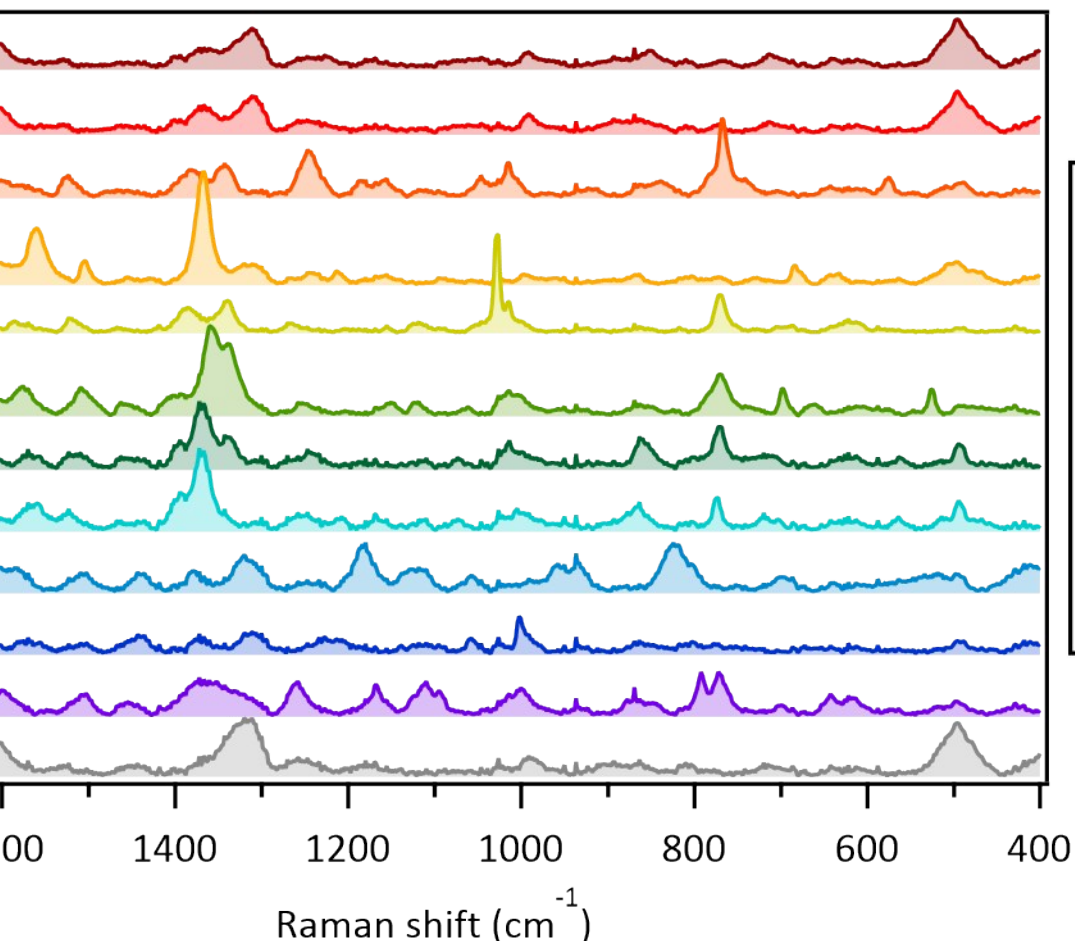
21

Supporting information

22 S-1 Surface enhanced Raman scattering spectra of synthetic cannabinoids.

23 S-2 Surface enhanced Raman scattering spectra of methanol extracts of herbal highs.

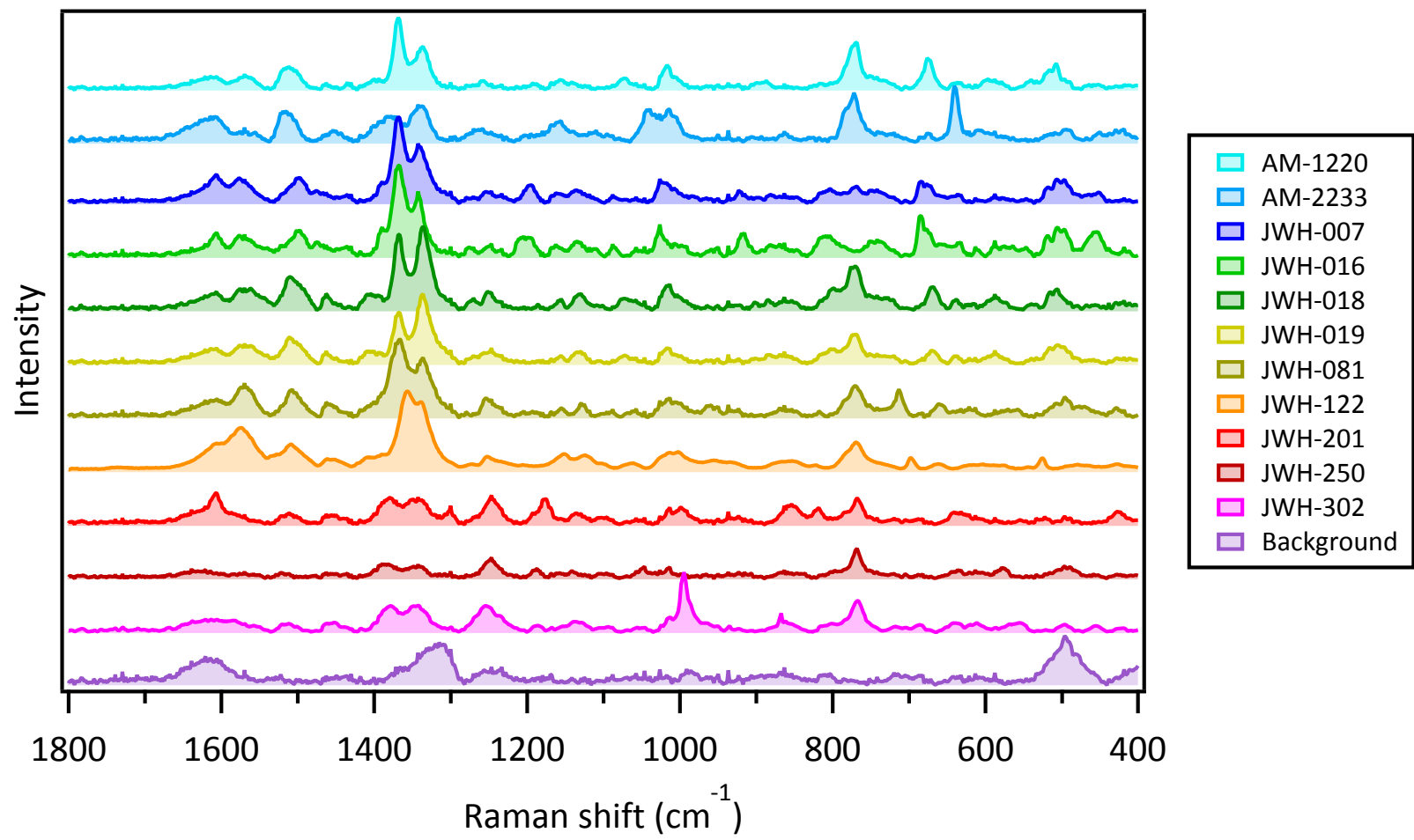
24



S-2

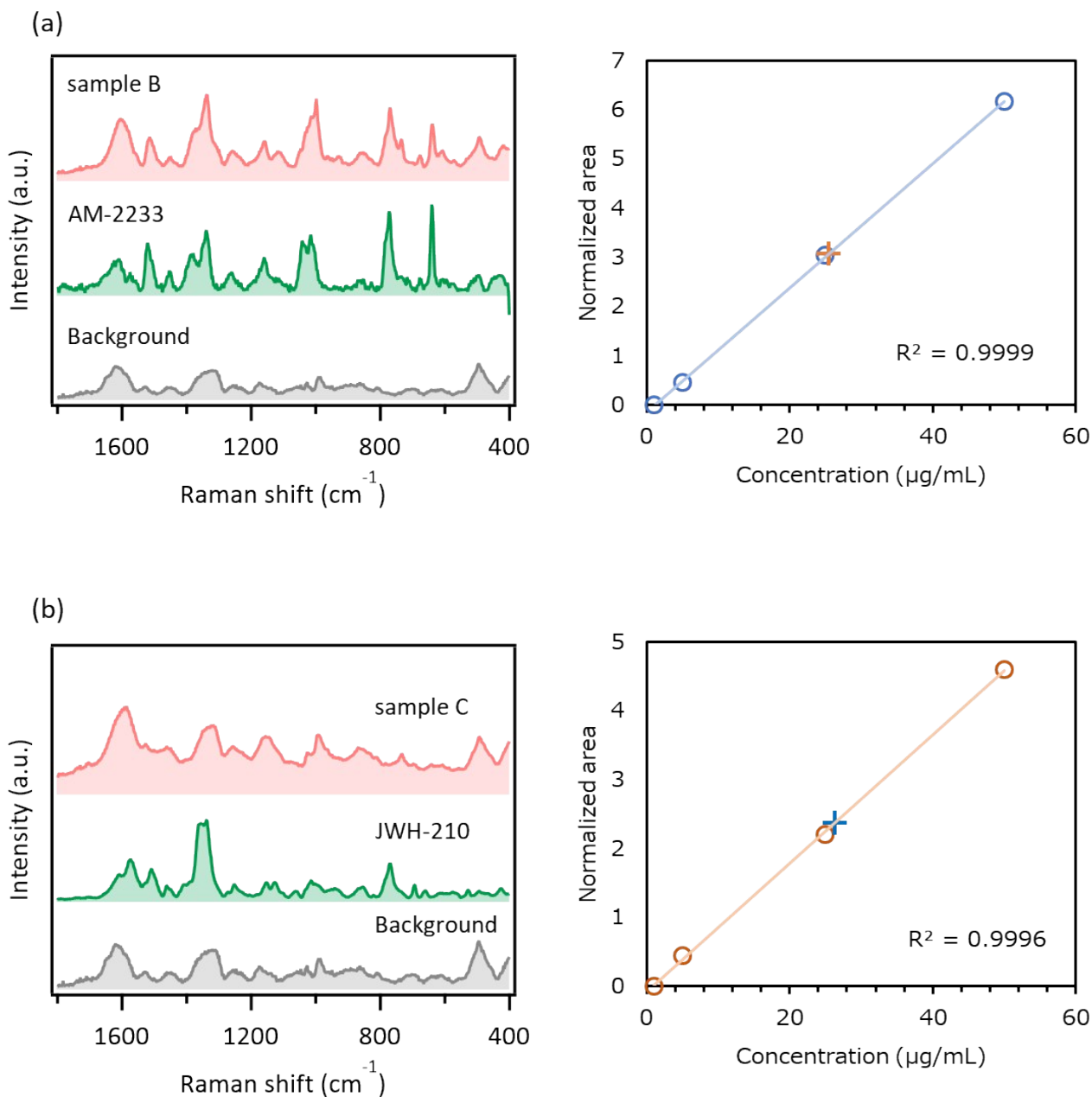
26 Figure S-1 Surface-enhanced Raman scattering spectra of synthetic cannabinoids obtained using a portable Raman spectrometer. The exposure  
27 time was 1 s and 100 frames were averaged. The background is the spectrum of methanol.

28



29

30 Figure S-1 (continued).

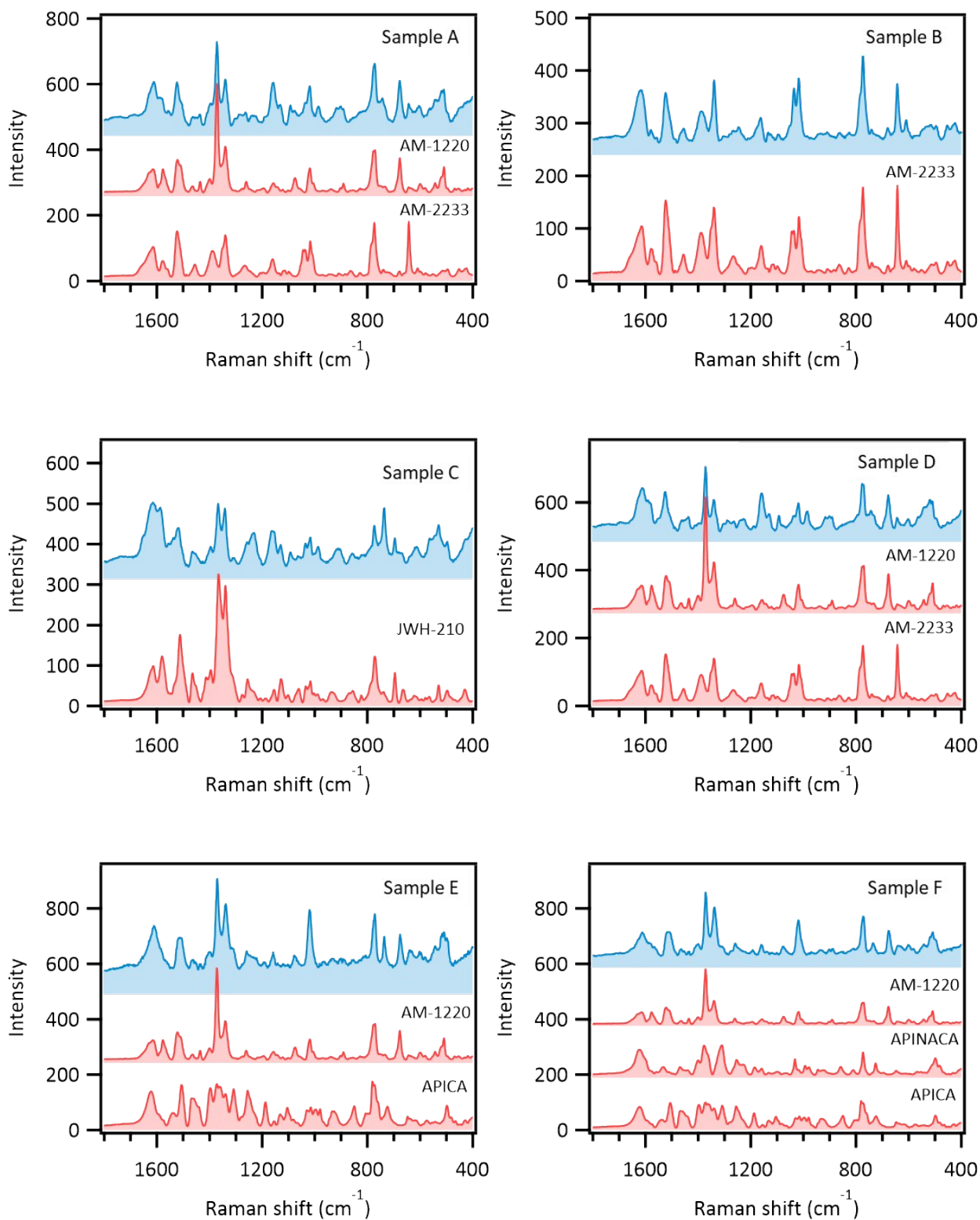


31

32 Figure S-2 Surface-enhanced Raman scattering (SERS) and quantitative analysis of (a) sample B and  
 33 (b) sample C. Left panels are SERS spectra of the herbal highs (direct analysis), standard solutions and  
 34 background. Right panels are results of quantification of the synthetic cannabinoids in the herbal highs,  
 35 performed by gas chromatography. Open circles indicate the plots of serial dilutions, linear lines  
 36 indicate the results of linear regression, and plus symbols indicate the plots obtained from the samples.

37

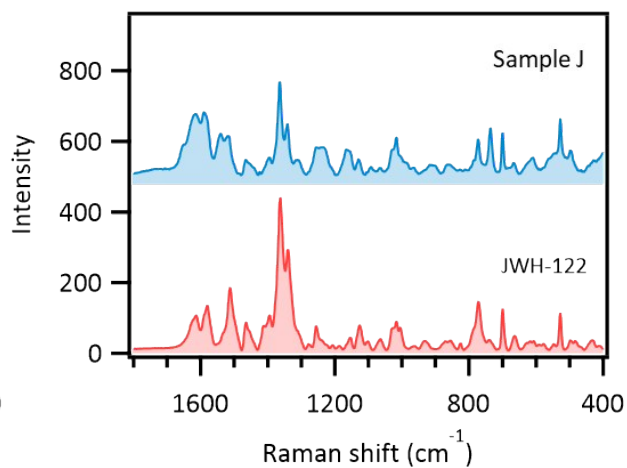
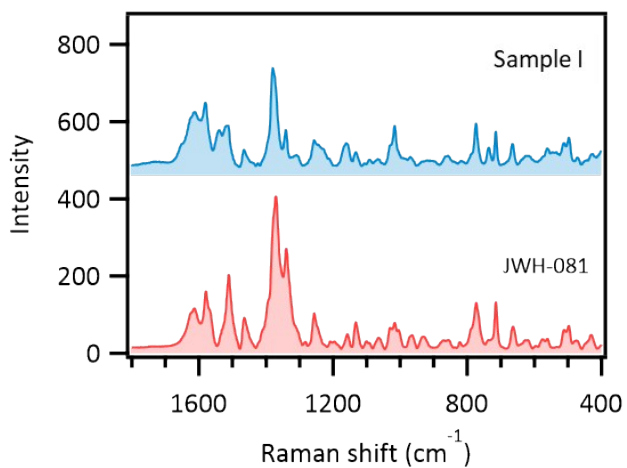
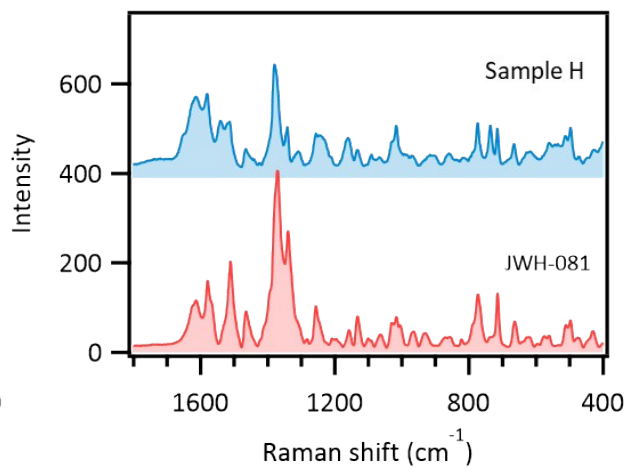
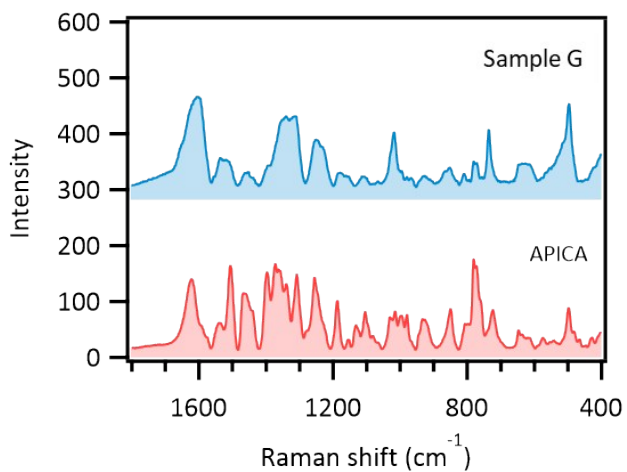
38



39

40 Figure S-3 Surface-enhanced Raman scattering spectra of methanol extracts of real herbal highs sold  
 41 on the street (blue) and standard synthetic cannabinoids (red). The spectra are offset for ease of  
 42 interpretation. These spectra were obtained using a Raman microspectrometer.

43



44

45 Fig. S-3 (continued)