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# MICROSCOPIC IMAGE AND SPECTRAL ANALYSIS OF GENUINE & COUNTERFEIT CURRENCY AS EXEMPLIFIED BY EXAMINATION OF INDIAN 2000-RUPEE NOTES

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**Abstract:** *With the introduction of the Indian 2000 Rupee notes (2000-INR) in November 2016, the production and circulation of counterfeit notes have increased exponentially. This increase has not stopped with the Reserve Bank of India's (RBI) attempts to develop awareness among the general public to assist the population to distinguish between counterfeit and genuine notes. The availability of Hi-tech printing technology has made it easier to imitate the security features of the notes. There have been extensive studies made on counterfeit notes using more traditional methods such as visual and microscopic studies. This paper focuses on different selective areas of both genuine and counterfeit notes using traditional methods and methods that include forensic image analysis and spectral analysis using the VSC 8000HS.*

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**Keywords:** 2000-Rupee note (INR), Fake Indian Currency Notes (FICN), Reserve Bank of India (RBI), Optimal Variable Ink (OVI), security features, counterfeits, image analysis, microscopic analysis, spectral analysis

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## Introduction

The larger 2000-INR notes were recently printed for the following reasons:

- The need for higher denominations because of inflation and economic growth
- Convenience for handling large transactions
- More economical than printing several notes of lower denominations
- Ability to hold larger sums of money in a wallet

In addition, the popularity for the larger 2000-INR note, along with the smaller note, the 500-INR, has continued to grow to the point that the banks have difficulty keeping up with the demand. To determine if the notes are genuine or not, bank tellers examine them by look, feel, and tilt during the transaction. When the counterfeit currencies are seized and sent

for forensic examination, the conventional tests are first conducted. The note's genuineness is then established after verification of the security features like the watermark, see-through register, latent images, the Optical Variable Ink, micro lettering and micro-printing, color shift, windowed security thread, intaglio printing, and the Ghandi portrait. In addition to using the conventional techniques, newer tests like spectral, microscopic, and image analysis have helped to distinguish genuine notes from counterfeits ones..

## Case Report

It is reliably known from local source that one person was involved in illegal trade of counterfeit Indian Currency notes and stored huge quantities of counterfeit notes in his house. The information was reported to the local Police Station and the Officer In-charge, along with staff, cordoned the house for the search. During the search, a good quantity of 2000-INR notes were recovered and a case was registered.

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Observation under normal light

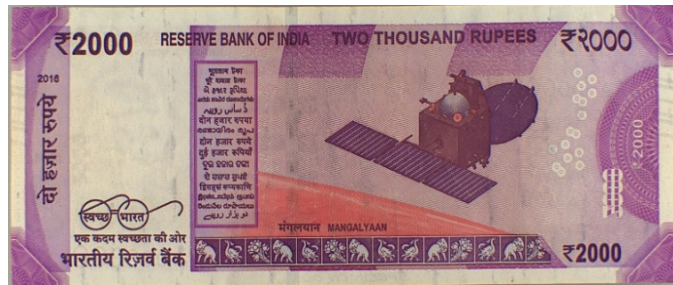


Figure 1a. A close-up photograph the front/back side of a genuine 2000-INR note.

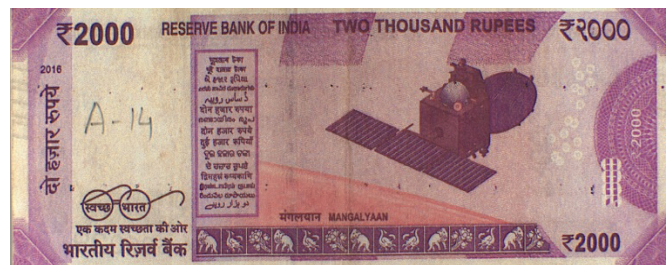


Figure 1b. A close-up photograph of the front/back side of counterfeit 2000-INR note.

Observation Under UV light

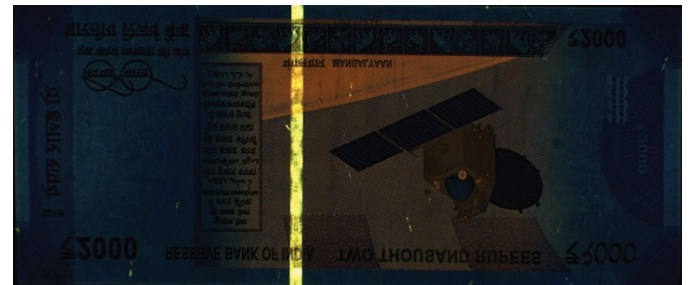


Figure 1c. A close-up photograph of the front/back side of genuine 2000-INR note under UV light at 365 nm.



Figure 1d. A close-up photograph of the front/back side of counterfeit 2000-INR note under UV light at 365 nm.

Subsequently, the seized notes were received in Tripura State Forensic Science Laboratory for examination to establish their genuineness.

Materials and methods

On receipt of the currency, the conventional methods of feeling, touching and tilting were used

along with the examination of different security features - essential points prescribed by the Reserve Bank of India. During the preliminary examination, these currency notes were found to be suspicious. Further efforts were made to conduct microscopic, spectral and image analysis to see if there were additional features. The absorption, image analysis and IR along with microscopic studies were



Non-printed area

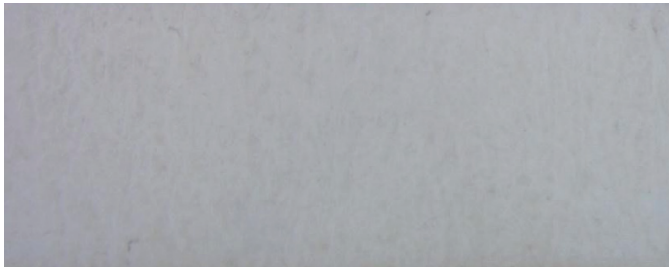


Figure 2a. A microscope image shows uniform background in a genuine note.



Non-printed area

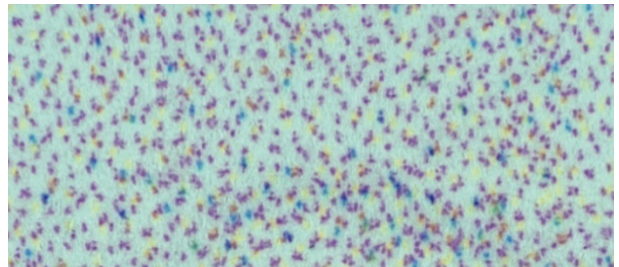


Figure 2b. A microscope image shows scattered colorful droplets in a counterfeit note.

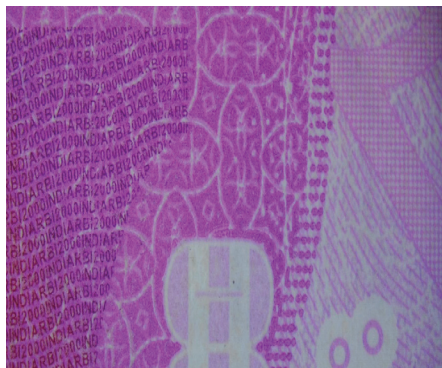


Figure 3a. A microscope image clearly shows the micro-letting in a genuine note.

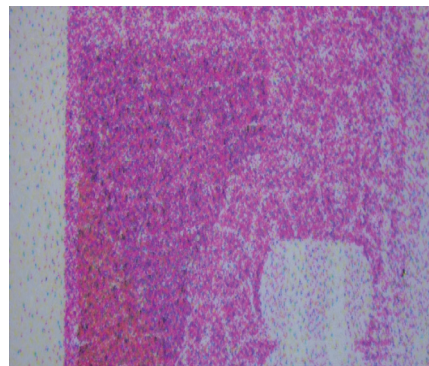
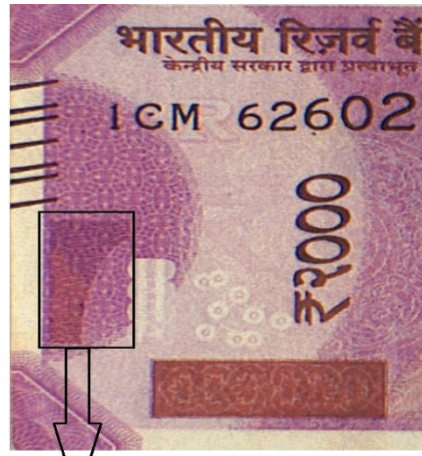


Figure 3b. A microscope image does not show micro-letting in a counterfeit note due to ink clogging.

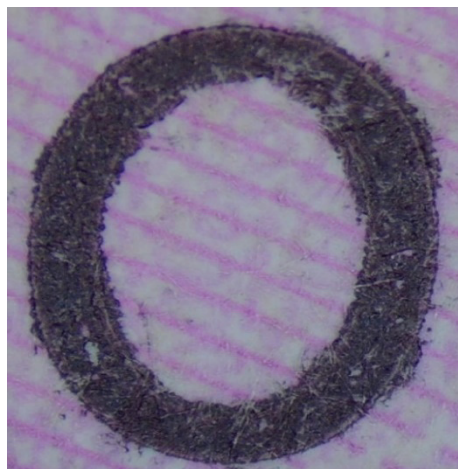


Figure 4a. A microscope image of the fourth zero (L to R) in the number panel of a genuine note.

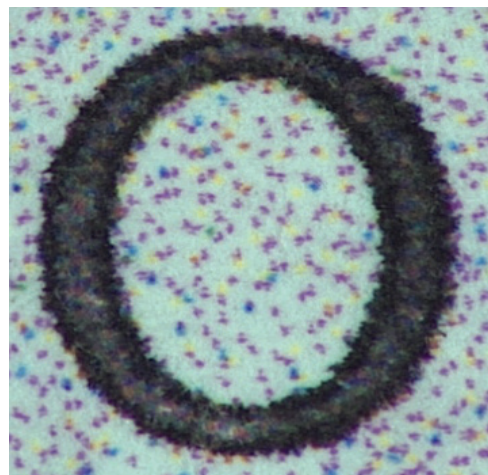


Figure 4b. MA microscope image of the fourth zero (L to R) in the number panel of a counterfeit note shows zig-zag edges with tri-color droplets of ink.

conducted on both the genuine and counterfeit notes for comparative study [4-6].

The spectral characteristics were studied using the VSC8000HS. The photographic view of genuine and counterfeit 2000 INR under ordinary light and UV are shown in Figure 1a - 1d. Further, the study of different physical parameters of 2000 INR genuine and counterfeit notes were found to be helpful for comparison coupled with other instrumental methods.

### Microscopic study

Genuine currency notes are generally made of cotton mixed with linen and different types of chemicals to increase its tensile strength. The chemistry of the pulp composition used for government currency notes is kept secret for various reasons.

A Trinocular HD Stereomicroscope Model-RELIFE RL M3 T was used to examine three of the genuine and three of the counterfeit notes. In all

the samples, the identical microscopic images were captured and the features were compared (Figure 2a and Figure 2c). In the case of the genuine note, the microscopic images showed that these notes were all uniform, spotless, and grain free resulting from the process of making pulp for government currency (Figure 2a). Whereas, in the case of the counterfeit currency notes, only tri-colored droplets were scattered throughout the surface of the notes (Figure 2b). The differences seen in the microscopic images are due to different paper quality and different printing technology used for processing bank currency notes. The microscopic image of the unprinted area of the currency paper in both genuine and counterfeit notes suggest different origins/qualities and also different printing methods. In addition, the microscopic images of micro-lettering are shown in Figures 3a and 3b. The zeros in Figures 4a through 4d, show differences suggesting different composition/technology used for printing the genuine and the counterfeit currency [2,7,8]. The printing characteristics like scattered tiny



Figure 4c. A microscope image of numeral denomination (2000) shows OVI in a genuine note.



Figure 4d. A microscope image of numeral denomination shows a non-impact dot matrix pattern in a counterfeit note.

droplets with satellite drops of tri-color ink, zig-zag/non uniform edges and ink clogging on micro-lettering area lead to the conclusion that the counterfeit currency notes were printed by using inkjet printing technology.

### Forensic Image Analysis

The color composition in the RGB (red, blue and green) plane and the histogram analysis show different histogram views for the security threads (Figures 5a and 5b, 6a and 6b) [9-10].

### Observation under IR

The genuine and counterfeit 2000 INR notes were exposed to IR fluorescence at 850 nm. In the case of the genuine notes, no fluorescence ink in sensing could be observed on the number panel. However, in the case of counterfeit notes, the number panel shows the characteristics of fluorescence (Figures 7a and 7b) [7-8].

### Spectral Analysis

The spectral analysis was conducted using the VSC8000HS. The quality of examination and opinion drawn in any case depends on a greater number of scientific methodologies adopted in the process of examination. In this study, in addition to conventional tests, the spectral studies have been used to form more conclusive opinions. The results found in the spectral studies are encouraging in distinguishing genuine from counterfeit notes.

### Conclusion

In this case, the microscopic, spectral and image analysis have been conducted coupled with other conventional methods to differentiate between the genuine and counterfeit notes. The conventional methods such as watermarks, micro-lettering, OVI (Optical Variable Ink), latent image, see through register, security thread, intaglio printing and blind marks. have been systematically examined to confirm

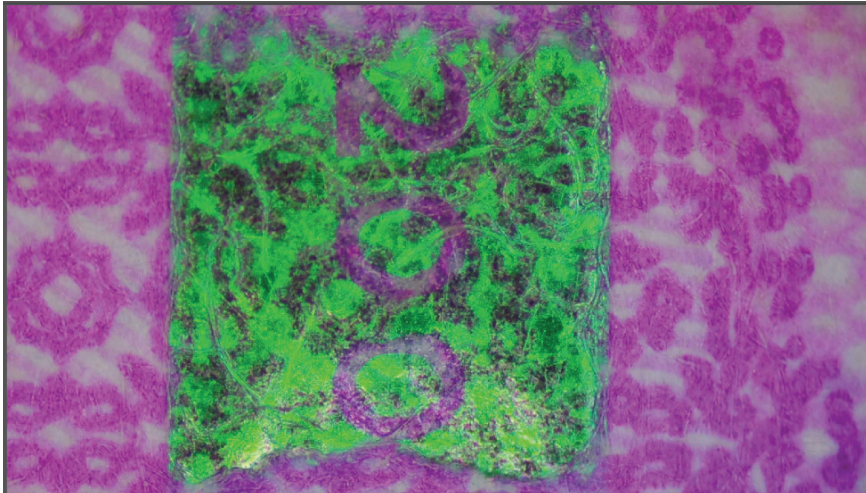


Figure 5a. Image of the one windowed security thread of a genuine note.

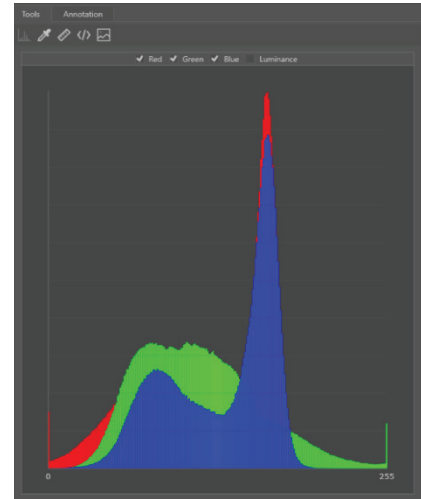


Figure 5b. RGB color histogram of a genuine note.

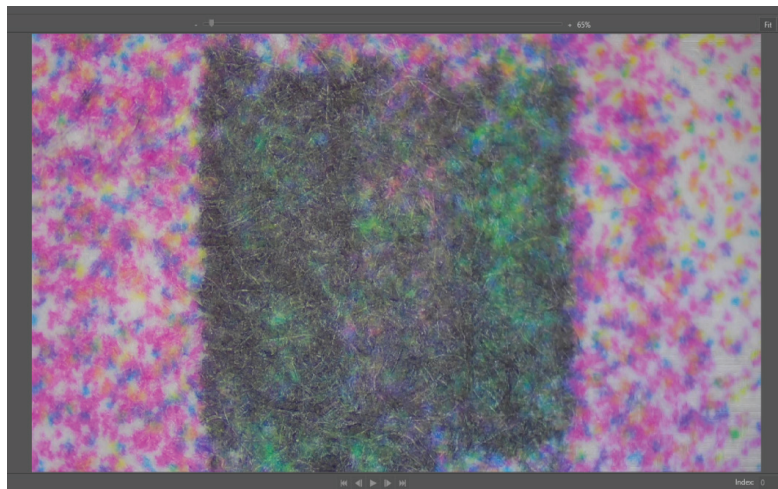


Figure 6a. Image of the one windowed security thread of a counterfeit note.

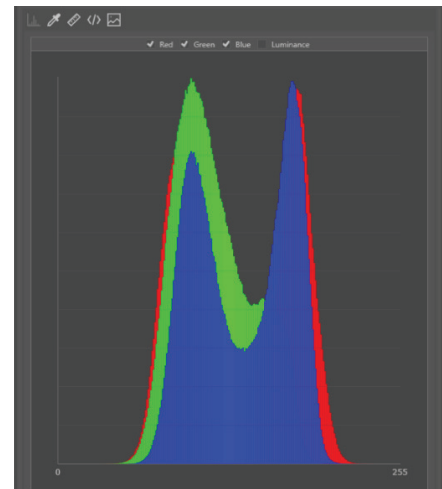


Figure 6b. RGB color histogram of a counterfeit note.

that the disputed notes were counterfeit. The spectral analysis also provides the different spectra at OVI and security thread areas. The information obtained from each area is complementary in discriminating the features of genuine and counterfeit notes and can be extended by increasing the number of zones analyzed. Further, the image analysis of one of the windowed security threads of both genuine and counterfeit notes was studied using the Foclar Mandet software and their RGB color histograms that differentiated between genuine and counterfeit notes. These scientific applications are fast, non-destructive and suitable for forensic document examination and

their results are reproducible in the court of law for effective testimony leading to successful prosecutions of those who are counterfeiting the Indian Rupee 2000 notes. This information is also useful for bank officials, money exchangers, security agencies and document examiners who need to distinguish genuine from counterfeit notes.

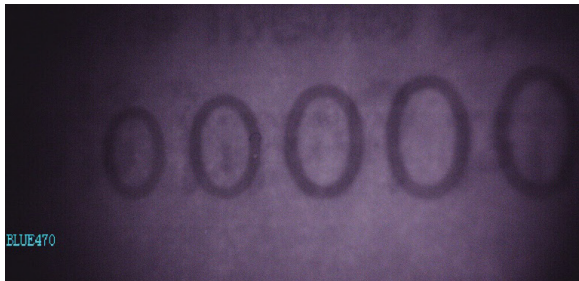


Figure 7a. IR fluorescence view of number panel in a genuine note.



Figure 7b. IR fluorescence view of number panel in counterfeit note.

Ref = Reflectance, Abs = Absorption, Flu = Fluorescence, Tra = Transmittance, N = Normalised, d/dw = Differential, Av = Average

- 1 Abs | ABS SPECTRA OF GENUINE 2000 NOTE ON OVI
- 2 Abs | ABS SPECTRA OF GENUINE 2000 NOTE ON OVI
- 3 Abs | ABS SPECTRA OF GENUINE 2000 NOTE ON OVI
- 4 Abs | ABS SPECTRA OF FAKE 2000 NOTE ON OVI
- 5 Abs | ABS SPECTRA OF FAKE 2000 NOTE ON OVI
- 6 Abs | ABS SPECTRA OF FAKE 2000 NOTE ON OVI

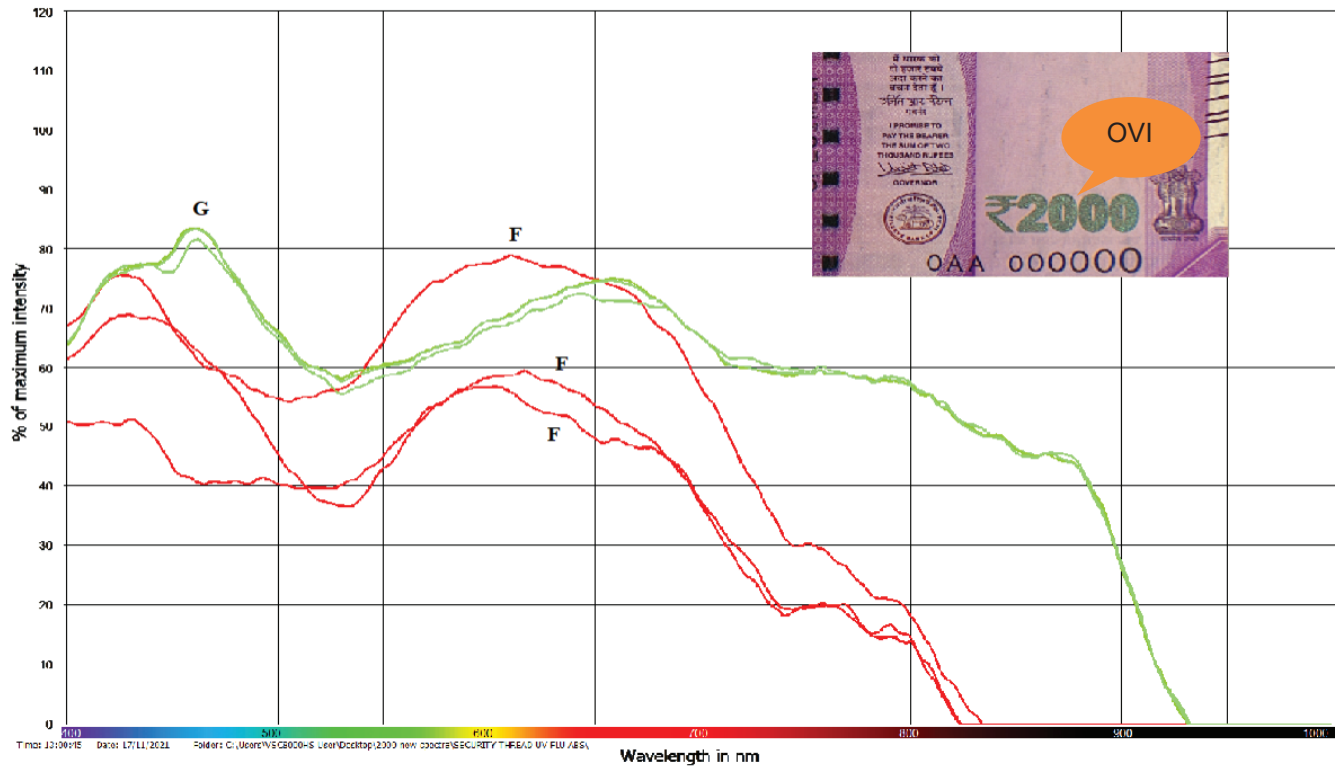


Figure 8. Absorption spectra recorded on O (Zero) of OVI on genuine (green line) and counterfeit (red line) notes.

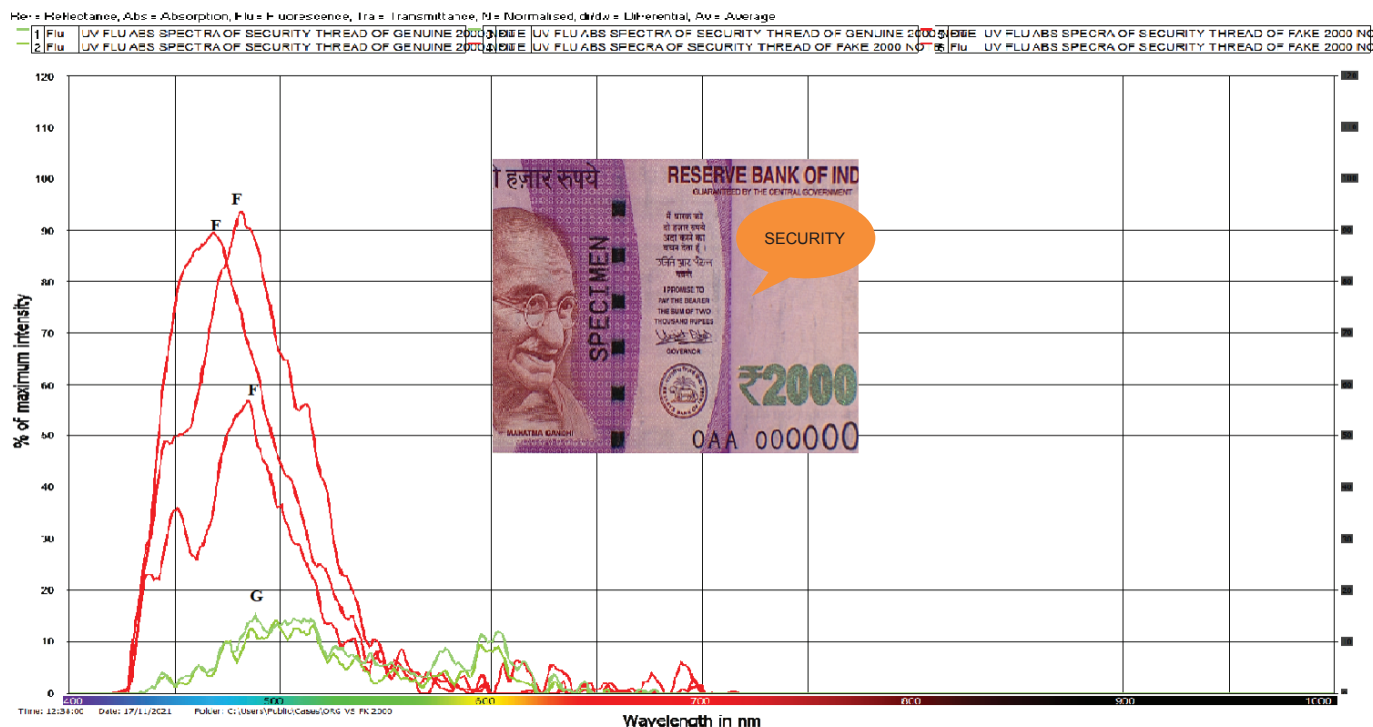


Figure 9. Fluorescence absorption spectra on security thread on genuine (green line) and counterfeit (red line) notes.

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