

Analysis of Ink Aging Using FTIR-ATR and UV-Vis Spectroscopy

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Structured Abstract

Background: Ink aging studies are crucial in forensic document examination and conservation science, where determining the authenticity and timeline of documents is essential. Over time, environmental factors such as heat, humidity, and UV light can cause inks to degrade, affecting their chemical structure and appearance. Traditional ink analysis often involves destructive methods, but modern spectroscopic techniques such as Fourier Transform Infrared Spectroscopy with Attenuated Total Reflectance (FTIR-ATR) and Ultraviolet-Visible (UV-Vis) Spectroscopy offer non-destructive alternatives.

Methods: This study analysed the aging behaviour of fountain pen and cartridge inks under controlled conditions over a 56-day period. FTIR-ATR was used to monitor chemical changes in functional groups, while UV-Vis Spectroscopy was employed to observe optical degradation patterns through absorbance spectra. Samples were artificially aged under consistent exposure to UV light, heat, and humidity. Spectral data were collected and analysed at multiple time points (Day 0, 1, 4, 7, 14, 35, and 56). The data from both techniques were then compared to see how chemical and optical changes are related.

Results: FTIR-ATR analysis revealed consistent degradation in chemical bonds such as C-H, C=O and C-O-C over time, indicating oxidation and polymer breakdown. UV-Vis analysis showed a general decrease in peak absorbance and wavelength shifts (bathochromic and hypochromic), reflecting chromophore degradation. It was found that cartridge inks exhibited more rapid degradation than fountain pen inks, with significant reductions in intensity and shifts in λ_{max} . A strong correlation between chemical and optical degradation was observed, demonstrating the combined effectiveness of both techniques.

Conclusion: In conclusion, this research shows that FTIR-ATR and UV-Vis Spectroscopy are effective methods for studying ink aging. The findings can help in forensic document analysis and conservation work by providing a better understanding of how inks degrade over time. This study also highlights the importance of combining chemical and optical analysis when examining ink stability and document authenticity.

Keywords: Ink aging, FTIR-ATR, UV-Vis spectroscopy, forensic document analysis, chemical degradation.

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