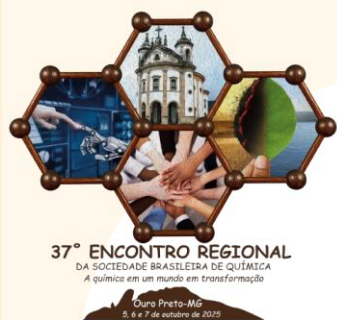




Comparative Evaluation of Rutin and Resveratrol as Reductants in Gold Nanorods Synthesis

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ABSTRACT

Gold nanorods (AuNRs) exhibit unique optical properties suitable for biomedical applications. However, traditional methods of obtaining properties often rely on toxic chemicals. This work investigated the performance of two natural reductants, rutin and resveratrol, on the seedless synthesis of AuNRs. Characterization was performed using UV-Vis spectroscopy and Dynamic Light Scattering (DLS). The results demonstrated that rutin produced AuNRs with LSPR at 718 nm, while AuNRs prepared using resveratrol showed LSPR at 657 nm, displaying distinct optical behaviors. These findings suggest that natural reductants hold promise for more sustainable wealth approaches, warranting further research to improve conditions and expand applications.

Keywords: Gold nanoparticles; Rutin; Resveratrol; Green synthesis; Gold nanorods.

Introduction

Gold nanoparticles (AuNPs) have emerged as versatile nanomaterials due to their unique physicochemical and biological properties, such as high colloidal stability, intense longitudinal surface plasmon resonance (LSPR), and potential for functionalization in therapeutic and diagnostic applications [1]. These characteristics make AuNPs widely applicable in areas such as biomedicine, controlled drug delivery systems, optical sensors, cosmetics, and even the food industry, particularly due to their morphological versatility and absorbance across the UV-Vis spectrum [2]. Several chemical synthesis methods for AuNPs have been developed using a wide range of reducing and stabilizing agents to maintain colloidal stability [3]. Rutin and resveratrol have emerged as natural flavonoids with significant antioxidant properties. Their electron-donating capabilities allow the reduction of gold ions (Au^{3+}) to metallic gold (Au^0), thus boosting the nucleation and growth of gold nanostructures. In this context, this work aimed at the synthesis of gold nanorods using resveratrol and rutin, comparing the performance of these two natural reductants.

Experimental

Synthesis of AuNRs

In this study, a seedless synthesis method was employed to prepare AuNRs using rutin and resveratrol as reducing agents. Chloroauric acid (0.1 mol/L), silver nitrate (0.025 mol/L), and either rutin or resveratrol (0.055 mol/L) were sequentially added to a CTAB solution (0.055 mol/L) under continuous stirring for approximately 5 minutes. Subsequently, a sodium borohydride solution (0.0045 mol/L) was added in a 25 °C water bath. The reaction mixture was then heated to 70 °C and maintained for 4 hours. The synthesized nanorods were characterized using UV-Vis Spectroscopy and Dynamic Light Scattering (DLS).

Results and Discussion

The progression of the reactions was indicated by a gradual color change: blue for resveratrol and brown for rutin. UV-Vis spectra confirmed the formation of AuNRs, showing two characteristic plasmonic bands: one at ~520 nm, attributed to the transverse electron oscillation, and another at longer wavelengths, corresponding to the longitudinal mode. For AuNRs synthesized with resveratrol, the longitudinal band was observed at 657 nm, whereas rutin produced a more red-shifted band at 718 nm (Figure 1). The simultaneous presence of both transverse and longitudinal bands confirms the formation of anisotropic nanostructures of the nanorod type. These spectral shifts are associated with differences in nanoparticle aspect ratio, suggesting that rutin favored the generation of structures with stronger absorption in the near-infrared (NIR) region. This effect may be related to the higher number of hydroxyl groups in the rutin molecule compared to resveratrol, which could have enhanced both its reducing capacity and its interaction with gold surfaces, thus favoring anisotropic growth. Preliminary DLS analysis indicated average dimensions of 40.8×17.5 nm for the resveratrol AuNRs.

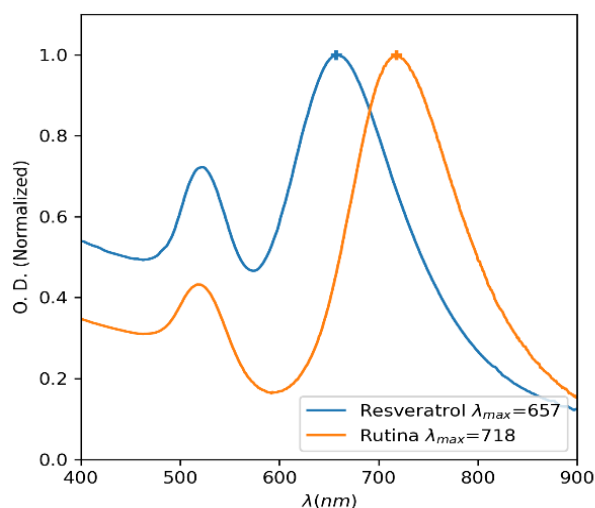
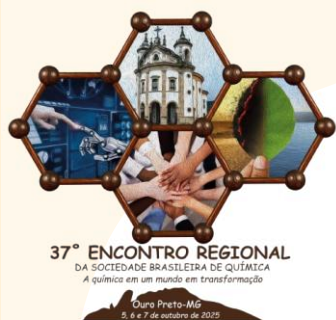


Figure 1. UV-Vis spectra of gold nanorods

Conclusions

Both rutin and resveratrol proved effective as reducing agents in the seedless synthesis of gold nanorods. AuNRs synthesized with resveratrol exhibited a longitudinal plasmon resonance at 657 nm and smaller average dimensions, whereas those obtained with rutin showed a red-shifted band at 718 nm, associated with stronger absorption in the NIR region. These differences demonstrate that each reductant enables the production of AuNRs with distinct optical properties, broadening the spectrum of potential applications. While resveratrol-derived nanorods may be advantageous in systems requiring absorption in the visible region, rutin-derived nanorods are more suitable for biomedical applications that benefit from NIR absorption, such as photothermal therapies. Therefore, both flavonoids represent promising and complementary green routes for the synthesis of AuNRs. Furthermore, additional characterization, including ongoing DLS analyses for the rutin system, will provide deeper insights into the similarities and differences between these two reductants.

Acknowledgments

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References

1. LIMA, M. H. C. T. de et al. **Unraveling applications of gold nanoparticles in dentistry: a scoping review.** *Journal of Dentistry*, [S.l.], v. 156, p. 105685, maio 2025.
2. KARNWAL, A. et al. **Gold nanoparticles in nanobiotechnology: from synthesis to biosensing applications.** *ACS Omega*, Washington, v. 9, n. 28, p. 29966–29982, jul. 2024.
3. Wang, W., Li, J., Lan, S., Rong, L., Liu, Y., Sheng, Y., Yang, B. **Seedless synthesis of gold nanorods using resveratrol as a reductant.** *Nanotechnology*, 27(16) 2016.
4. LEVCHENKO, L. A. et al. **Synthesis and study of gold nanoparticles stabilized by bioflavonoids.** *Russian Chemical Bulletin, International Edition*, v. 60, n. 3, p. 426–433, mar. 2011. DOI: 10.1007/s11172-011-0083-7.