Raman spectroscopy biomarkers in seminal plasma: Non-invasive detection of male infertility

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The World Health Organization (WHO) defines infertility as a couple's failure to conceive after one year of regular unprotected intercourse. Male infertility accounts for approximately 50% of cases, often independently, with seminal plasma (SP)—comprising 95% of ejaculate volume—playing a key role in sperm function modulation. Raman spectroscopy analysis of SP offers insights into its molecular makeup, enabling advanced diagnostics for male fertility.

In this pilot study, we acquired in vitro Raman spectra (400-1900 cm^{-1}, 532 nm excitation) from 70 dried SP samples. Using Multivariate Curve Resolution (MCR), we resolved spectra into three main components: tyrosine, spermine phosphate hexahydrate, and protein-dominant material. Distinct spectral differences emerged between normal and abnormal samples, notably in peak intensities at 625, 1440, and 1008 cm^{-1}, achieving 79% specificity and 95% sensitivity for classification.

To our knowledge, this represents the first investigation identifying biochemical Raman markers distinguishing normal from abnormal SP per WHO criteria (sperm count, motility, morphology). These results advance male infertility diagnostics and underscore the need for novel strategies in reproductive health.