1. Project Goal

The primary goal of this project is to explore the capability of Positron Annihilation Lifetime Spectroscopy (PALS) to detect chemical modifications and structural changes in biological samples, particularly blood clots, through the measurement of positronium lifetimes. The research aims to determine whether different chemical fixation methods influence these lifetimes, thereby establishing positronium as a sensitive nanoscale probe for biomedical applications. PALS has emerged as a pivotal non-destructive technique in material science, offering insights into the microstructural characteristics of materials, including the detection of voids and defects at the nanometer scale. This study aims to extend the application of PALS to the biomedical field, specifically in the analysis of plasma clots and pulmonary thrombi obtained from patients.

2. Description of Research

This study involves fixing blood clots using various chemical agents formaldehyde, glutaraldehyde, and ethanol under a range of concentrations and temperatures (22°C, 37°C, and 40°C). PALS is then used to measure the resulting positronium lifetimes and intensities in each sample as shown in figure 1. These data are analyzed to identify subtle changes in intra-molecular voids, which reflect structural and chemical modifications induced by fixation. Positronium annihilation lifetimes and intensities are known to provide valuable information on the size and quantity of defects in a material's microstructure, such as voids or pores. In the context of blood clots, understanding these microstructural characteristics could have significant implications for medical diagnostics and treatment strategies. The work builds on prior investigations that utilized PALS alongside Scanning Electron Microscopy (SEM), ATR-FTIR, Micro-CT, and histopathology to characterize both in vitro and patient-derived clots.

3. Reasons for Attempting This Research Topic

Blood clots are a leading cause of morbidity and mortality globally, often referred to as the "number one killer disease." Despite their clinical significance, current diagnostic tools do not adequately detect early or nanoscale structural changes in clots. The ability to assess such changes using a non-destructive, highly sensitive method like PALS could greatly enhance diagnostic accuracy and therapeutic monitoring. Furthermore, understanding how chemical fixation alters biological structures is essential for improving sample preparation methods used in biomedical research.

4. Substantial Results Expected

The research is expected to yield key insights into how chemical fixation methods impact positronium behavior and, by extension, the structural integrity of biological specimens. These findings may refine the application of PALS in medical diagnostics and research, enabling earlier detection of clot-related abnormalities and a better understanding of pathological processes. Ultimately, the work could contribute to the development of novel diagnostic tools and influence clinical practices related to cardiovascular and clot-associated diseases.

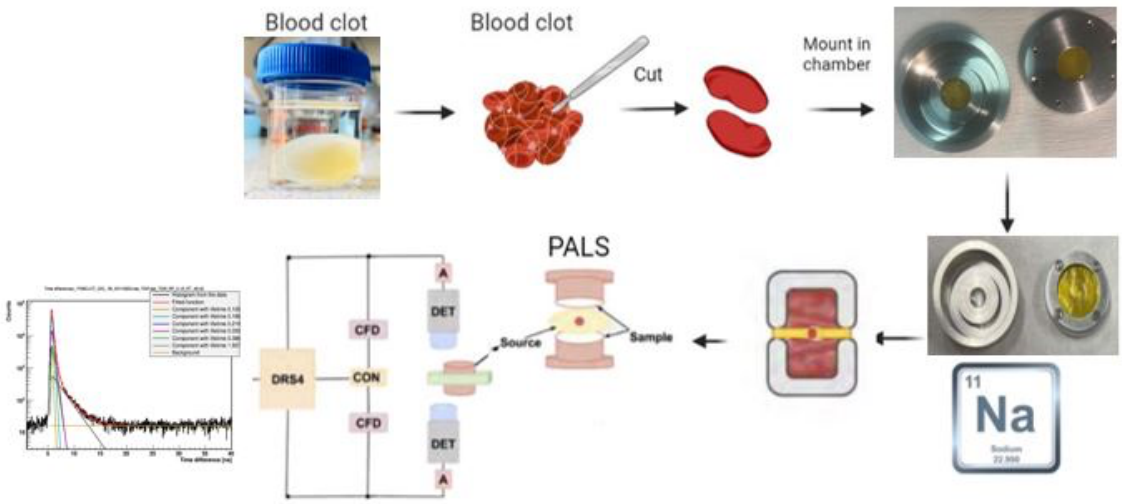

Figure 1: Schematic Plasma Blood clot PALS measurement workflow.