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## PAPER

# Investigating the Z-scan technique for quantifying circulating cell-free DNA (ccfDNA) extracted from blood plasma as a potential biomarker for various cancers

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Supplementary material for this article is available [online](#)

## Abstract

The Z-scan technique is a nonlinear optical method that has found applications in characterizing various materials, particularly those exhibiting nonlinear optical response (NLOR). This study applies the continuous wave (CW) Z-scan technique to examine the NLOR in terms of the nonlinear optical phase shifts ( $\Delta\Phi_0$ ) exhibited by the ccfDNA extracted from blood plasma samples collected from a group constituting 30 cancer-diagnosed patients and another group constituting 30 non-diagnosed individuals. The cancer group exhibited significantly higher  $\Delta\Phi_0$  versus incident power slopes compared to the non-cancer group (0.34 versus 0.12) providing a clear distinction between the two groups. The receiver operating characteristic (ROC) curve analysis of the results indicates a clear separation between cancer and non-cancer groups, along with a 94% accuracy rate of the data. The Z-scan results are corroborated by spectrophotometric analysis, revealing a consistent trend in the concentration values of ccfDNA samples extracted from both cancerous and non-cancerous samples, measuring 3.24 and 1.41 respectively. Additionally, more sensitive fluorometric analyses of the respective samples demonstrate significantly higher concentrations of ccfDNA in the cancer group, further affirming the correlation with the Z-scan results. The study suggests that the Z-scan technique holds promise as an effective method for cancer detection, potentially contributing to improved oncology diagnosis and prognosis in the future.

## 1. Introduction

Cancer is one of the main contributors to disease burden and mortality globally. Cancer incidence has steadily climbed over time, and this trend is anticipated to last for quite some time. In the year 2020 around 10.0 million people died from cancer with an estimated 19.3 million new cases in 185 countries worldwide [1]. Nearly 200,000 people in Bangladesh are said to battle cancer each year, taking a terrible toll of 150,000 lives [2]. Frequent late-stage diagnosis is a significant factor in the high mortality rate among cancer patients. Early cancer identification could significantly reduce this frightening fatality rate.

A biomarker is often used to detect cancer in a patient, but traditional detection methods are difficult to use for early-stage detection and are expensive. A biomarker is a measurable molecule that indicates normal or abnormal processes [3]. In the relentless pursuit of improved cancer diagnostics and early detection, the assessment of circulating cell-free DNA (ccfDNA) in blood plasma has emerged as a promising avenue of research. Circulating cell-free DNA consists of fragments released into the bloodstream because of cell apoptosis and necrosis [4]. In healthy people, normal germline DNA serves as its main source, while in cancer patients, some ccfDNA also comes from tumor cells [5].