ABSTRACT

Black tea is a globally consumed beverage around the world, generating a substantial revenue worldwide. Black tea is composed of a number of compounds, which have a positive effect on the consumer when consumed up to the therapeutic limit, else can lead to health complications. Till now, tea tasting is based on the tea-taster's score and is purely subjective and varies with the individual's state of mind. Thus, to obtain a quantitative measurement of the different taste-affecting compounds in black tea, an effective instrumental approach is the need of the hour. This research work is aimed to rapidly detect the presence of different analytes in black tea. Three distinct molecules, tannic acid (TAN), theophylline (TH), and total theaflavin (TF), were chosen as the target molecules. Tea mainly consists of two different types of compounds- polyphenols and methylxanthines. The presence of the TAN (polyphenol) determines tea astringency, TH (a methylxanthine derivative) is responsible for bitterness as well as astringency. The total theaflavins (TF) in black tea are responsible for the aroma and flavour of tea. The employment of nano-crystals of metal and rare-earth metal oxides and molecularly imprinted polymer (MIP) based electrodes is explained for the selective determination of the analytes. To comment on the morphological variations of the electrode materials, Fourier transform infrared (FTIR) spectroscope, field emission scanning electron microscope (FESEM), and an ultraviolet visible (UV-Vis.) spectroscope have been used. To begin with, an electrochemical sensing system has been reported, consisting of a modified graphite electrode (Nd_2O_3@GP) for the detection of TAN in black tea. To enhance the performance of the electrochemical system, MIP technology was used. This MIP based electrode showed a limit of detection (LOD) 37 nM and the electrode displayed an accuracy of 96.315%.

The next work discusses two different approaches for the detection of TH. Initially, the analysis of voltammetric responses in real black tea samples, while modifying the bare graphite electrode with samarium oxide nanoparticles, is highlighted. Additionally, the thermally stable properties of the Gd2O3 NPs have been explored to enhance the MIP electrode's response. In contrast to the initial investigation, the later MIP-based electrode showed reasonable molecular selectivity, stable behaviour over a sufficiently long time and the LOD 2.004 μM was significantly improved. Compared to the standard HPLC protocol, the electrode demonstrated an accuracy of 91.3% in real samples of black tea.

In the following section, the detection of total theaflavins has been explored using a modified

graphite electrode and a MIP-based electrode whose surface has been modified by $NiCo_2O_4$ nanoparticles. The MIP-based electrode showed a LOD of 13.89 μM with satisfactory repeatability, with an RSD value of 0.71%. This electrode shows a prediction accuracy of 92.6% when immersed in real samples of tea.

Towards the end of the thesis, an attempt was made to successfully detect two analytes, epicatechin (EC) and TH, using a single CuO modified electrode. This CuO@GP electrode demonstrated a linear range of 50.0–100.0 μM for both analytes, with a LOD of 4.0 μM for EC, 27.0 μM for TH. Recently, an approach was made to develop an e-tongue based on MIP-based electrodes. This array of MIP sensors was able to successfully detect the traces of TAN, TF and TH in a single tea sample. DPV responses from the tea sample were obtained and subjected to PCA clustering, which shows a satisfactory segregation among the three different analytes in a black tea sample with a separability index (SI) of 32.4305. Further, this same setup was used to discriminate among five different samples of black tea. In this latest approach, the Gradient Boost algorithm has been used to develop a robust cognitive model, which showed R^2 value of 0.967. The t-SNE algorithm on the fused data successfully discriminated among the five different samples of black tea. Addition of a few more specific sensors, targeting other major tea bio-markers to this array, may be considered for further study. The developed system is poised to be used as a taste profiling instrument on a day-to-day basis in the tea industries.