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AMBIENT TEMPERATURE DRIFT COMPENSATION METHOD FOR BENZENE GAS SENSOR RESPONSES USING SENSOR BASELINE RESISTANCE

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ABSTRACT

In benzene monitoring, utilization of miniaturized gas sensors, i.e., metal-oxide semiconductor (MOS) gas sensors have gained popularity due to its high sensitivity, low cost and portability. Despite these qualities, the sensors are very prone to drift from various causes, i.e., ambient temperature. Most drift compensation methods compensate drift based on the only "already-known" drift-causing parameter (i.e., ambient temperature) without considering other parameter that would be affected as well due to the induced drift-causing parameter (i.e., sensor baseline). In ambient temperature fluctuation, it is a gas sensor nature to drifting regardless of under any exposure, either in clean air or in gas exposures. As ambient temperature varied, sensor resistance at baseline (in clean air exposure), R_a is drifted as how sensor resistance in gas exposure, R_g is drifted. Since sensor response is usually estimated as the ratio of sensor resistances (R_a/R_g), hence the drifted baseline resistance, R_a by ambient temperature variation will "drag" its "untreated" drift-effect in R_a/R_g throughout further analysis. Considering this effect of drifted baseline, thus, the aim of this study was to compensate drift of ambient temperature in MOS gas sensor responses using method that utilizes sensor baseline resistance (named RT-method), whereas another method without sensor baseline resistance utilization (known as T-method) was performed as comparison. The study also looks into identifying the sensor drift in MOS gas sensor responses, which later compensation of the drift have been performed using and without sensor baseline resistance (also known as RT- and T- methods respectively). The efficiency of both methods have then compared in compensating the drift. Drifted responses from two MOS gas sensors (TGS2600 and TGS2602) were acquired by exposing the sensors to benzene at several concentrations (0.5, 1, 5 and 10 ppm) at variation of 25, 30 and 35°C ambient temperature. The drifted responses were compensated by using T- and RT- methods, and then were verified and validated in their efficacy of compensating drift. Drift reduction percentage, and gas (benzene) concentration estimation accuracy were used to assess compensated responses performance. For the first assessment, RT-method has outperformed T-method in reducing the drift significantly (up to 64% drift has been reduced in TGS2600 sensor responses and up to 92% in TGS2602 sensor responses for RT-method, compared to only up to 45% and 57% drift reduced in the respective sensors for T-method). Meanwhile, for the second assessment, the estimation accuracy of benzene concentration has improved surprisingly as well using RT-method compensated responses with estimation errors only at 0.2 ppm (mean) and 0.8 ppm (maximum), much lower than the estimation errors when using T-method compensated responses that are at 1.2 ppm (mean) and 4.4 ppm (maximum). These assessments have verified and validated the outperformance of RT-method efficacy over T-method, and therefore, has proven the significance of utilizing sensors' drifted baseline resistance in improving drift compensation attempt of ambient temperature in MOS gas sensor responses.

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TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Benzene is well-known with its hazardous toxicity as human carcinogen and possible human mutagen (Grigoryan et al., 2018). Inhalation to the vapours of this colourless and odourless gas can cause effects to the central nervous system (Orujov & Jafarova, 2018) and serious permanent damage to the blood system even at relatively low concentrations (Thomas et al., 2014). As a part of gasoline component, benzene concentration in air is majorly contributed from the emission of mobile sources (Kimbrough et al., 2014). It is also contained in cigarette smoke, petrochemical industry and in manufacturing that requires aromatic solvents or glues such as rubber production, shoe manufacturing, and spray-painting (Kamal & Rashid, 2014). All of these sources of emission are the contributors for the existence of benzene exposures in the atmosphere of many people's living environment (i.e., outdoor (Kerchich & Kerbachi, 2012), indoor (Ferrero et al., 2017), workplace (Kamal & Rashid, 2014; Williams, 2014) and car interior (Librelon et al., 2018).

Occupational Safety and Health Administration (OSHA) has regulated the standard concentration for benzene permissible exposure limit (PEL) at 1 ppm of eight-hour time-weighted average (TWA), and 5 ppm of short-term exposure limit (STEL) for industry in general, construction and shipyard employment (OSHA, 2012a). Benzene is recommended to should be kept below 10 ppm exposure limit if feasible, with action level of 0.5 ppm 8-hour time-weighted average (TWA) (OSHA, 2012b).

Since benzene exposure in atmosphere is very perilous to human health even at low concentration level, its presence in air is vital to be monitored (Mohamed et al., 2013). Real-time air quality monitoring is a very promising tool to investigate the presence of benzene in air at certain focused area (Sun et al., 2015). It is a collection of instantaneous readings from air monitoring equipment (i.e., gas sensor array based) that