ISSN 0975-2366
DOI:https://doi.org/10.31838/ijpr/2020.12.04.609
Research Article

# Physiochemical Effects of Nano Particles from Welding Fume on Rumaila Oil Field Welders by Using FESEM-EDS

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Received: 01.10.20, Revised: 07.11.20, Accepted: 15.12.20

## ABSTRACT
Welding, as a process, is a standard manufacturing method used to combine metals and produces complex aerosols of potentially dangerous metal fumes and gases. Welding procedures, the length of contact, and other workplace conditions other than welding gases were the leading causes that affected the welder's health. Welding gas particles all seem to be somewhere around or less than one micrometer in diameter and less than 100 nanometers in diameter. Vapors are present during welding, whether or not a smoke plume is visible. Owing to their small scale, the vapors can infiltrate the alveoli deeply into the respiratory system.
This study aimed to determine the elements and gases and their relation with welder health by using FESEM and EDS x-ray technique. The welders from north rumaila (NR)and south rumaila (SR) the oil field (24 people) were selected for this study and by using the disposable mask to capture the welding fume to determine the nanoparticles of toxic elements, and the results show clinical signs for three persons in SR compare with two persons in NR. On the other hand, the presents of chromium, bromine, argon, and cerium in NR, lack in SR. At the same time, vanadium was found in SR and zero in NR.
Generally, other elements like aluminum, copper, palladium, magnesium, lanthanum, iron, and vanadium were observed in both NR and SR in different concentrations; after viewing the NR and SR workshop, the notable mistake was the absence of safety equipment like welding fume extractors and other kinds of HEPA filters.

**Keywords:** welding fume, FESEM, EDS, nanoparticle, welder’s health

## INTRODUCTION
The welding process is among the most critical industrial applications. Welders active in welding work for at least eight hours of continuous work per day and are exposed to a wide range of welding conditions. Fumes, as objects produced during the welding process, are solid particles from the welding of consumables, the base material, and any coatings on the base material. This vaporized material is condensed into small particles fumes [1, 2].
Industrial processes generate dangerous material fumes that can include nickel (Ni), chromium (Cr), manganese (Mn), iron (Fe), and gasses, including specific carbon monoxide, nitrogen oxide, and ozone[3]. Welding techniques and products being used mislead workplace conditions other than welding aerosols[4].
Many long-term welders or staff subjected to welding fumes might be affected by certain forms of respiratory problems such as pulmonary symptoms, bronchitis, metal smoke fever, changes in lung function, sensitivity to high and low respiratory infections, and also potential development of many other diseases such as lung cancer[5-7].
Possible negative consequences of welding fumes are being debated for several years, particularly with the growing use of manual metal arc welding and gas welding, which typically includes numerous alternate respiratory processes[8].
The welding procedure requires connecting the metal parts using heating sources the pieces to a melting temperature[9]. The procedure increases the levels of metal fumes, consisting mainly of fine and ultra-fine particles[10]. The epidemiological studies proved that exposure to such fumes are related to metal smoke fever and intensified respiratory symptoms [11-13]. Also, welder’s health witness an increased incidence of inflammatory lung diseases such as asthma and chronic bronchitis[14]. A significant reduction in lung function often accompanies long term exposure to welding fumes;[15] however, this correlation is mostly found only in smoking welders, indicating a potential link between welding smoke and cigarette smoke in the pulmonary response.

Chromium, nickel, and manganese are known as impurities that do not pose the same toxic danger as pure elements. The oxidation states of chromium and manganese also impact their toxicity[16].

When studying airborne particles such as those in welding gases, the essential aspect to note is the particle size. That's because a particular characterization methodology only offers reliable data about a specific range of sizes. Energy dispersive spectroscopy with scanning electron microscopes (SEM-EDS) gradients measured fume particles that are smaller than half a micrometer because the SEM beam penetrates and samples the volume of such small particles rather than just their surface [17].

Nanoparticles are capable of crossing the pulmonary epithelial barrier into circulation[18]. Metal oxides cause inflammation reactions in human cardiac microvascular endothelial cells and human aortic endothelial cells[19]. Exposure to metal fumes is related to cardiovascular toxicity, and the type of reaction relies on the particles' physicochemistry [20].

## MATERIALS AND METHODS

Table (1) lists the full-time selected welders 24 persons from both the north and south Rumaila workshop and the observed clinical signs. According to the Occupational Safety and Health Administration (OSHA 2014), a sampling method to determine the airborne by wearing the welders with disposable masks filters for eight working hours was applied.

The disposable mask filters were divided into four equal sections. Each section pointed in the middle to be the analysis point for SEM-EDS and forward to the electron microscope unit in pharmacy college – Basra University to be detected.

**Table 1: list the number of welders exposed to welding fume with and without clinical signs and control**

| Group | Number of welders | | Control |
|---|---|---|---|
| | With clinical signs | Without clinical signs | |
| North Rumaila | 2 | 4 | 6 |
| South Rumaila | 3 | 3 | 6 |

For the FESEM-EDS study, the samples were placed onto the specimen stub using double-sided carbon tape and glued down the mask surfaces on it. Then, after blowing, tightened all the stubs on the specimen holder to eliminate non-adherent bits. Qualified specimens were loaded onto FESEM from Zeiss Supra 55 VP (Germany) via low voltage airlock windows to surpass the coating technique and stop charging. They were using a high resolution and sharp picture of a secondary electron detector (SE2) with fixed magnification and well-calibrated Bruker Quantax EDS XFlash 6/60 (Germany) (Germany).

## RESULTS AND DISCUSSION

FESEM–EDS performed an elemental analysis of welding mask filters collected from the welder. Almost every object analyzed and evaluated was formulated of many kind of metals typically contained in the fumes, as shown in table (2).

The FESEM–EDS elemental examinations revealed that the metals in context were complex together but heterogeneously distributed between the different specific samples that were screened.

**Table 2: Atomic concentration percentage for elements in the north and south Rumaila workshops welder's masks (by EDS)**

| No. | Elements | Atomic Concentration means % | |
|---|---|---|---|
| | | North Rumaila | South Rumaila |
| 1 | Aluminum | 23.21 | 23.15 |
| 2 | Copper | 1.29 | 1.78 |
| 3 | Palladium | 0.35 | 0.32 |
| 4 | Magnesium | 0.69 | 0.53 |
| 5 | Chromium | 0.07 | 0 |
| 6 | Lanthanum | 1.12 | 1.30 |
| 7 | Iron | 0.05 | 0.23 |
| 8 | Vanadium | 0 | 0.78 |
| 9 | Bromine | 2.44 | 0 |

| | | | |
|---|---|---|---|
| 10 | Argon | 0.08 | 0 |
| 11 | Cerium | 0.31 | 0 |

As seen in table (2) and Fig. (1), the results vary between north and south Rumala workshop, primarily because of surface temperature incomplete assumptions, which determines vapor composition [21]. The secondary reason, as explained by Heile, D. C. Hill and Sreekanthan [22,23], they contrasted the design of the gas gathered with the electrode of a composition different from that of the base plate, the composition of the gas is determined almost entirely by the size of the electrode.

Tables (2,3 and 4) observed the highest concentrated Aluminum element with the same percentage for both North and South rumaila, and levels were decreased for Copper, Lanthanum, Magnesium, Iron. Some other features observed in North rumaila like Bromine, Cerium, Argon, and Chromium compare with apparent Vanadium in south rumaila.

From the other side, Images in Figures (1) show the fine and also ultrafine particles with nano diameter from 10 nm to 400 nm accumulations in mask filter thread. Welding fumes typically aggregate with nanometer-sized particles [24-26]. Deposited welding particles had diameters that often ranged from 0.2 to 1.0 µm in size, with individual particles as small as 10 nm[27].

Another very prominent symptom amongst those welders subjected to Aluminum was exhaustion, concentration problems, and depression [28,29]. However, exposure to welding smoke has indeed been found to have an immunosuppressive and immunotoxic impact on welders[30]. Pathological inspection of lung tissue obtained after welding reveals inflammatory cells and pulmonary injury signs, persistent bronchitis; productive cough is a common cardiovascular and respiratory complaint of workers[5-7].

Bast [31] study and compare the Aluminum concentration for retired and still work welders exposed to Aluminum in the same factory, which was higher in non-retired; on the other hand, the exposure time will affect the nervous system. Copper and Iron embroiled in metal fume fever, especially in prolonged exposure to vaporized copper that coated the electrode [5]. Its acute onset (approximately 4 hours after exposure) is described this fume fever and sometimes imitates a flu-like disorder. [32], while the Magnesium level was elevated 40 times when inhaled during welding and accumulated in the lung. [33].

The growth in industrial technologies has become evidence for some rare elements and their bioaccumulation [34]; these elements' redox effect on biological effects has been reported with anti and pro-oxidant activities. [35,36].Palmer [37] studied the rare element cytotoxicity in rats and observed Lanthanum and Cerium fibrogenic in lung tissue. Recently and through a scanning electron microscope, with an energy dispersive X-ray examination, an individual with an occupational history of rare element exposure shows Lanthanum and Cerium particles in their lungs and interracial lung disease [38, 39].

**Table 3: EDX acquisition tables of elements show the variation of atomic concentration on surface of disposable masks in South Rumaila**

Spectrum: Acquisition 973

| Element | Series | unn. C [wt.%] | norm. C [wt.%] | Atom. C [at.%] | Error (3 Sigma) [wt.%] |
|---|---|---|---|---|---|
| Aluminium | K-series | 65.83 | 28.76 | 23.15 | 8.91 |
| Carbon | K-series | 72.99 | 31.89 | 57.67 | 26.43 |
| Calcium | K-series | 36.06 | 15.76 | 8.54 | 4.39 |
| Copper | L-series | 11.91 | 5.21 | 1.78 | 5.25 |
| Oxygen | K-series | 7.35 | 3.21 | 4.36 | 3.65 |

**Table 4: EDX acquisition tables of elements show the variation of atomic concentration on surface of disposable masks in North RumailaSpectrum: Acquisition 971**

| Element | Series | unn. C [wt.%] | norm. C [wt.%] | Atom. C [at.%] | Error (3 Sigma) [wt.%] |
|---|---|---|---|---|---|
| Carbon | K-series | 75.88 | 37.44 | 63.32 | 27.11 |
| Aluminium | K-series | 62.49 | 30.83 | 23.21 | 8.46 |
| Calcium | K-series | 29.06 | 14.34 | 7.27 | 3.57 |
| Copper | L-series | 8.19 | 4.04 | 1.29 | 3.78 |
| Oxygen | K-series | 3.26 | 1.61 | 2.04 | 1.92 |
| Palladium | L-series | 3.70 | 1.82 | 0.35 | 0.60 |
| Magnesium | K-series | 1.66 | 0.82 | 0.69 | 0.36 |
| Potassium | K-series | 2.33 | 1.15 | 0.60 | 0.43 |
| Chromium | L-series | 0.34 | 0.17 | 0.07 | 0.62 |
| Lanthanum | L-series | 15.49 | 7.64 | 1.12 | 2.87 |
| Iron | L-series | 0.28 | 0.14 | 0.05 | 0.44 |

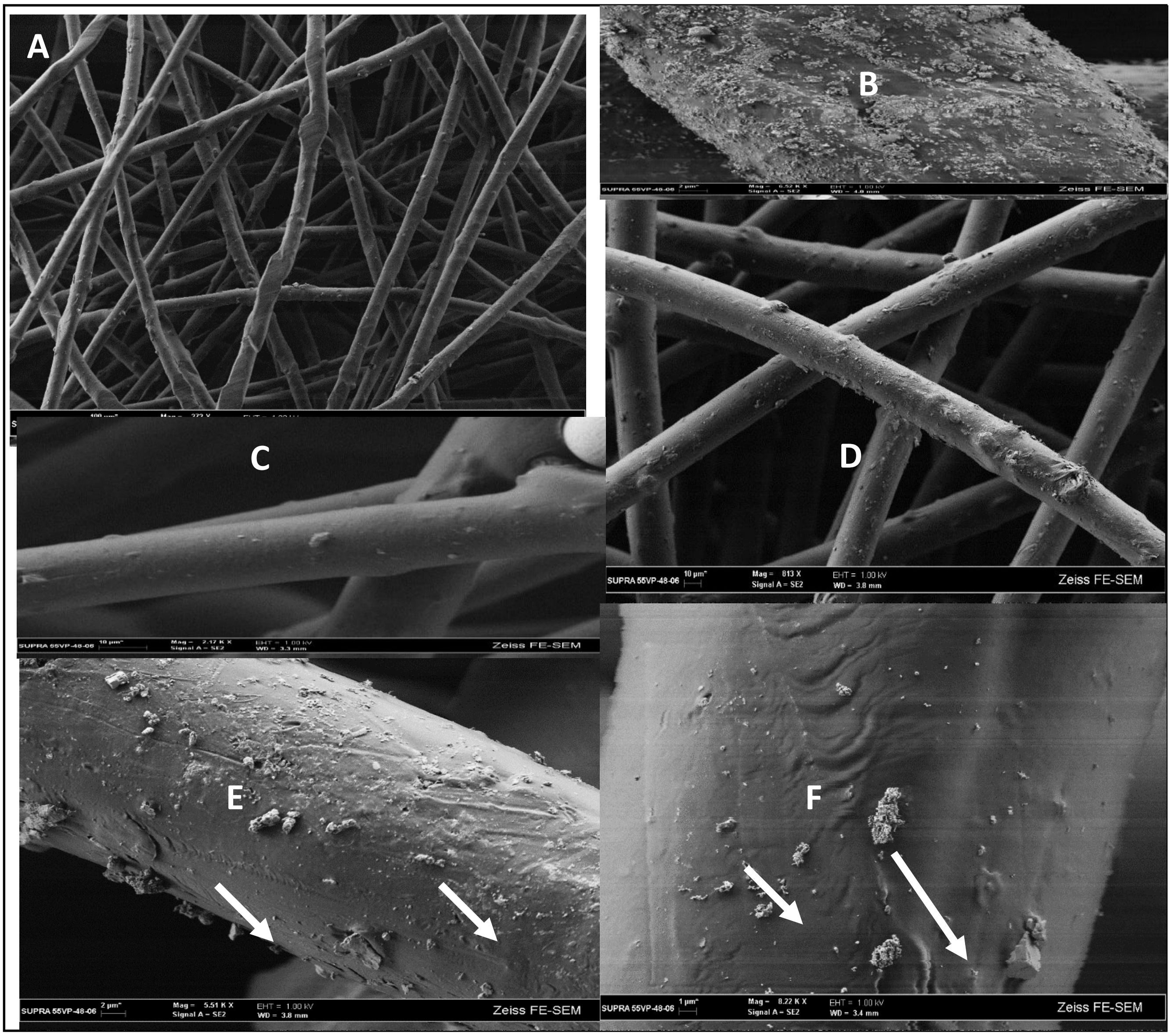


**Fig.1: FESEM images shows mask fibers with accumulation of elements particles. A) Aggregate of particles in all fibers in South Rumaila, B) Aggregate of particles in all fibers in North Rumaila , C) particle size between 150 nm .**

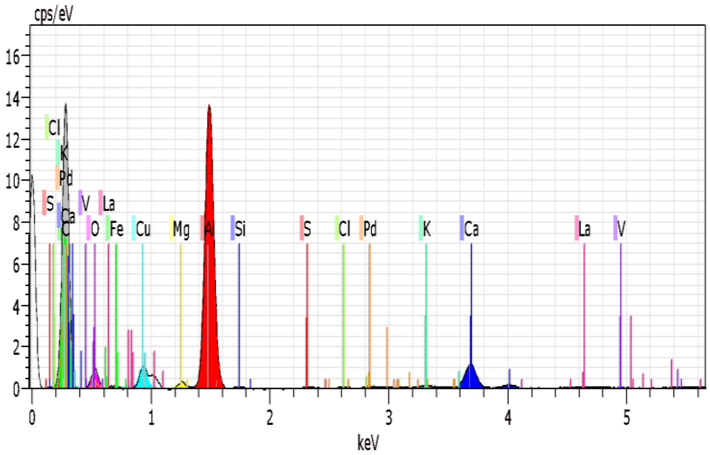


**Fig. 7: EDX spectra of elements distribution on surface of South Rumaila welder disposable masks**

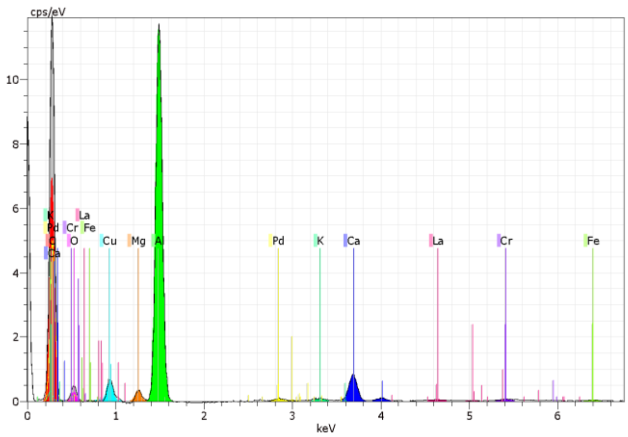


**Fig. 8: EDX spectra of elements distribution on surface of North Rumaila welder disposable masks.**

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