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Electrochemical Behavior Study of KF in Artificial Saliva Mediated by GCE Using Cyclic Voltammetry

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ABSTRACT

A new study used potassium fluoride (KF) in different concentrations (2% and 5%), one of the components in the complete denture as supported material. The study aims to find the electrochemical analysis by cyclic voltammetric (CV) technique of the physical properties of this material and the influence in artificial saliva (AS) by oxidation–reduction peak current in the oral cavity. This study used a glassy carbon electrode (GCE) as a working electrode, Ag/AgCL as a reference electrode, and platinum wire as an auxiliary electrode in the cyclic voltammetry cell. Different physical properties such as concentration, pH, scan rate, and reproducibility study were used in the potential-state. The results showed two oxidation peaks current at 1.4 and 0.75 Volt characterize to the artificial saliva and KF respectively, and one reduction peak current at -0.5 Volt for KF. All peaks were enhanced by increasing the concentrations and scan rates that indicate the study in the right response. Using different pH, the oxidation peak of KF disappeared in alkaline pH and enhanced in an acidic medium, so the KF ions act as an oxidative reagent in artificial saliva of acidic pH, and antioxidant in alkaline pH at a limited concentration of KF in the cavity of the mouth. The low concentration of KF (2%) used in the component of total denture is more favourable than the high concentration (5%). In addition, it is better to store the total denture in an alkaline solution after use to avoid any damage to the mouth cells.

1. Introduction

Studies in the electrochemical analysis of denture materials were increased in recent times to find the physical properties of saliva (Wang, et al., 2021; Radhi, et al., 2015; Radhi, et al., 2017; Radhi & Al-Mulla, 2015; Radhi, et al., 2018). The electrochemical impedance technique was used to study the effect of the different saliva composition solutions on the corrosion of metal. The results have obtained the order of corrosion rate: Artificial saliva ~ Glandosane ~ Krebs-Ringer solution < Artificial saliva without lactic acid ~ PBS (Brett & Muresan, 2002). The corrosion behavior of the dental casting alloys of Ni-Cr-Mo in different percentages was studied in artificial saliva using electrochemical methods of cyclic potentiodynamic and potentiostatic techniques. The results find that the corrosion resistance of the Ni-Cr-Mo alloys is associated with the formation of passive film containing Ni(OH)(2), NiO, Cr(2)O(3), and MoO(3), on the surface (Huang, 2002).

Amine fluoride gel with 1.25% fluoride at different pH mixed with saliva after different times were studied in vitro to find the effectiveness at each pH and times present with

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fluoride ions (Hellwig, et al., 2010). Poly - Methyl Methacrylate (PMMA) a type of polymer used in the dental field, was studied by cyclic voltammetric technique to find the electrochemical properties at different temperatures. Thermodynamic parameters were determined for each of activated enthalpy (ΔH*), free energy (ΔG*), and entropy (ΔS*) for redox peak current to determine the effect of different temperatures on the composition of the dental material (Ibrahim & Radhi, 2021).

Different kinds of toothpaste contain 1400–1450 ppm of fluoride-containing different fluoride agents: amine fluoride (AmF), sodium fluoride (NaF), sodium monofluorophosphate (SMFP), potassium fluoride (KF), and a high-fluoride of 5000 ppm of toothpaste containing NaF were studied in vivo to find an agent of fluoride in saliva medium (Opydo-Szymaczek, et al., 2022). Twenty releases of hydroxyethyl methacrylate (HEMA)/methyl ethacrylate (MMA) as controls were examined in water. Fluoride emission from saliva dropped to 36% of its baseline levels (Adair, et al., 1994). The purpose of this study was to determine the impact of fluoride ions already present in complete dentures and the drawbacks of artificial saliva medium.

2. Materials and Methods

Artificial saliva (AS) was prepared by the scientific lab of Shafeeq comp (Iraq), KF was received from SD Fin-Chem Limited, Mumbai, 0.1M of HCl, 0.1M of NaOH used as a buffer solution, and deionized water was used in all experiments.

Instrumentation

The cell of cyclic voltammetry (CV) cell technique was used by added of 10ml of artificial saliva in this cell and immersing the glassy carbon electrode (GCE) as the working electrode, Ag/AgCl as the reference electrode and platinum wire as the counter electrode as shown in Fig. 1.

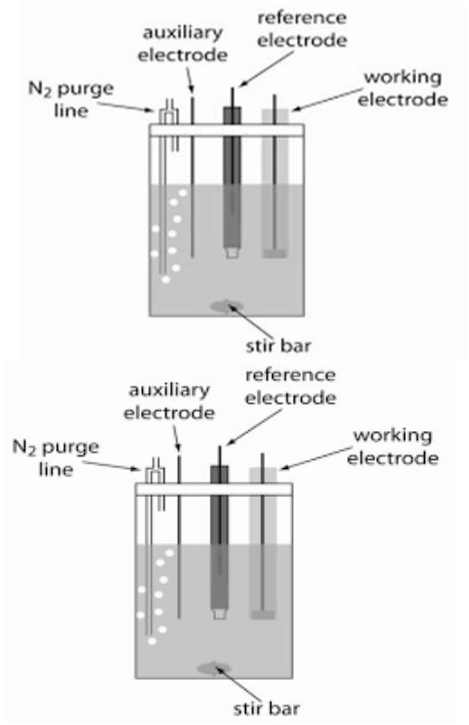

Fig. 1. Cyclic voltammetric cell

Then, the three electrodes were linked to a potentiostat (potentiostat/glvanostat) by NuVant System EZstat (U.S.A.), and a cyclic voltammogram, as depicted in Fig. 2, calculated the results.

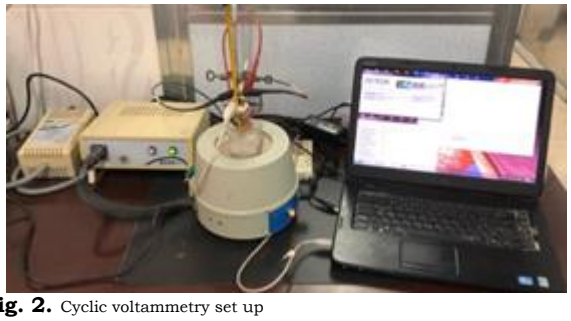

Fig. 2. Cyclic voltammetry set up

3. Results and Discussion

The compound of KF was used in the complete denture to further improve the physical and biological properties. These properties were identified using an oxidation-reduction study in artificial saliva using cyclic voltammetry.

Effect of Different Concentrations Study

The electrochemical properties of the different concentrations in aqueous solutions of (2% and 5%) KF, Fig.3 illustrated the voltammogram of KF at different concentrations in artificial saliva, which has oxidation peak current at a potential of +1.25 V for 2%KF and enhanced the oxidation peak of 5%KF at +1 V. It was found the KF acts as electro-catalyst of the oxidation process in the artificial saliva. The behavior of the KF used in improving the performance of complete denture in artificial saliva was observed from the calibration curve in Fig. 4, which shows the relationship between the oxidation peak current of 5%KF at different concentrations (0.01 - 0.06 mM) as in the equation:

Y= 428.57X + 69.667, with high sensitivity R2=0.9701

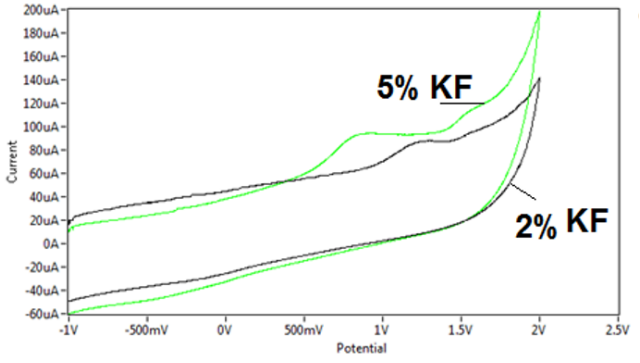

Fig. 3. Voltammogram of (2% and 5%) KF in artificial saliva on GCE versus Ag/AgCl as reference electrode at (0.1Vsec-1.)

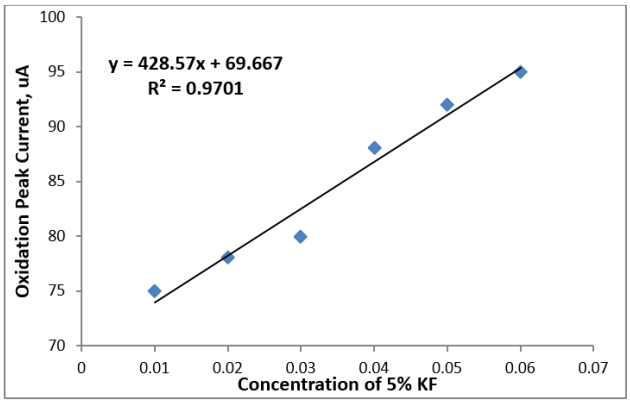

Fig. 4. Calibration curve of the oxidation peak current of 5%KF against to different concentrations (0.01-0.06 mM).

Effect of Different Scan Rates Study

It was confirmed that the cyclic voltammetric method was used in the study of the KF in artificial saliva to give good results that can be used in the research by changing the scan rates from 0.01 to 0.1 Vsec-1 and its effect on the oxidation peaks. Fig. 5 shows the cyclic voltammogram of the high and values of scan rates that affected the oxidation peak of KF with a systematic enhancement for the current as shown in Fig. 6, the calibration curve of the relationship between the oxidation peak current against the scan rates shows a straight line with an equation of (Radhi, et al., 2017).

Oxidation equation: Y = 668.33X + 15.344 with high sensitivity of R2= 0.9701

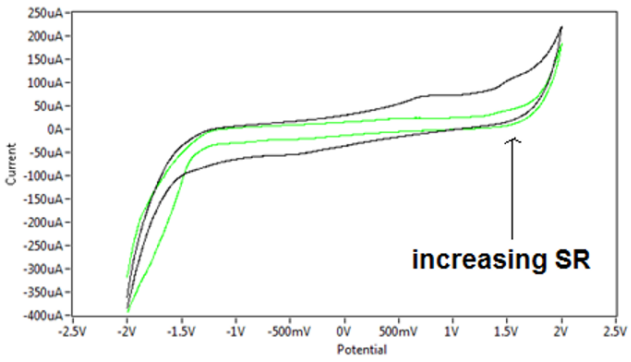

Fig. 5. Voltammogram of 5%KF in artificial saliva on GCE versus Ag/AgCl as reference electrode at different scan rates (0.01-0.1Vsec^{-1})

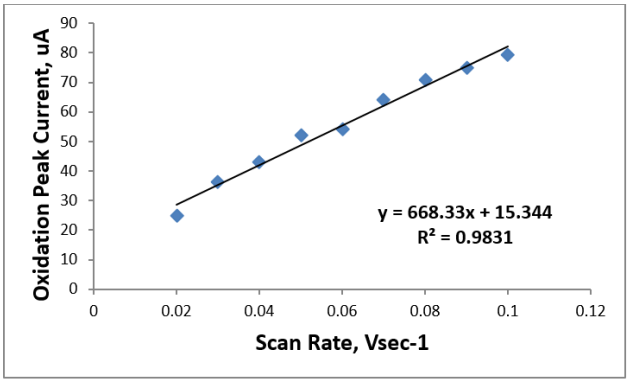

Fig. 6. Calibration curve of the oxidation peak current of 5%KF against to different scan rates (0.01-0.1 Vsec^{-1}).

Effect of Different pH Studies

In this part of the research, it was studied the effect of using different pH of the medium of artificial saliva on the oxidation peak current of the 5%KF was evaluated. It can be shown in Fig.7 that the oxidation peaks of the KF appeared in the acidic pH (3-6) and disappeared in the alkaline pH (7-9). Fig. 8 shows the maximum effect of the oxidation peak at pH 6, and the minimum value at pH 8. So, the KF in an acidic medium behaves as an oxidative reagent, while in alkaline pH is antioxidant (Baliga, et al., 2013). The presence of the KF in high concentration affects negatively the mouth cavity, as it leads to cell damage, especially in the acidic medium (Radhi, et al., 2019).

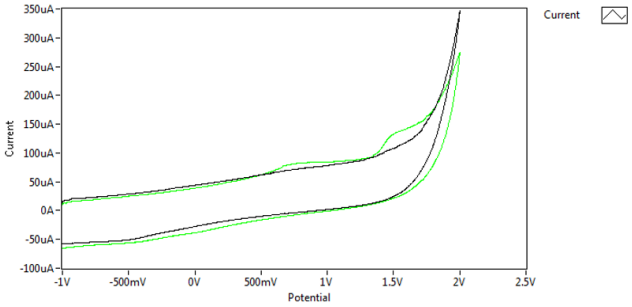

Fig. 7. Voltammogram of 5%KF in artificial saliva at different pH (green line for acidic pH and black line for alkaline pH) on GCE versus Ag/AgCl as reference electrode at 0.1Vsec-1.

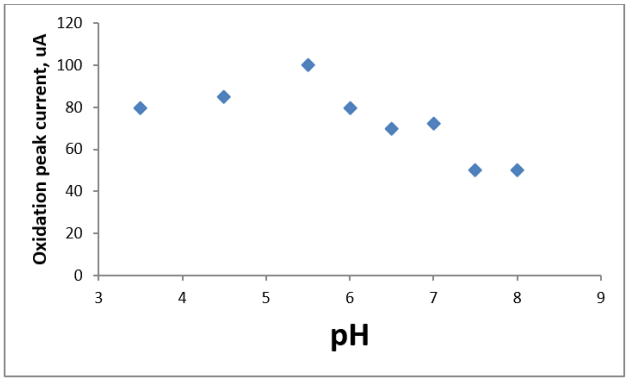

Fig. 8. Relationship between the oxidation peak current against to different pH (3-9)

Reproducibility Study

The reliability and stability of the cyclic voltmeter measurement results were examined by scanning technique of the cyclic voltammogram ten times. Figure 10 shows the cyclic voltammogram of KF artificially on the surface of GCE. It was observed that there is a good overlap between the oxidation-reduction peaks, which have depended in all experiments of cyclic voltammetry (Radhi, et al., 2015).

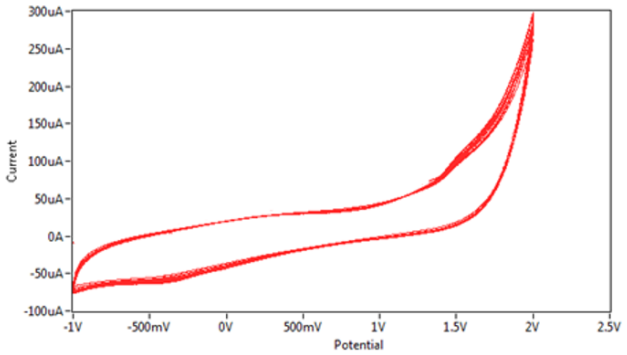

Fig. 9. Cyclic voltammogram of 5%KF in artificial saliva at ten times scanning

4. Conclusion

It can be concluded from the study that the treatment of the complete denture with KF gives new physical properties that have a role in improving its properties by studying its behavior using the electrochemical method in vitro study as in the following:

1. The high concentration of 5%KF affected oxidation behavior more than the low concentration of 2%KF.
2. In the acidic pH of the medium artificial saliva has an oxidative property that acts damage to the cell of the mouth.
3. In alkaline pH of the medium of artificial saliva has antioxidant behavior that is unaffected in the mouth cavity.
4. It is recommended to add ascorbic acid with the KF to the complete denture composition to maintain the alkaline pH.

Competing Interests

The author had no competing interests.

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