The Effects of pH on the Kinetics of the Follow-up Reaction of Dopamine o-quinone

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Introduction

What is Dopamine?
- Neurotransmitter that is part of the catecholamine and phenethylamine families
- Essential role in the function of reward-motivated behavior
- Various diseases and mental disorders arise from the deficiency of dopamine [1], such as:
  - depression
  - Parkinson’s disease
  - Schizophrenia

Background

For this experiment we used electrochemical methods to detect the pH threshold at which cyclization of dopamine o-quinone occurs and the relationship between pH and the rate of cyclization.

1960’s - Catecholamine Oxidation Pathways
- Experiments were carried out to determine the oxidation pathways of catecholamines [2]
- Cyclic voltammetry was partly used to determine these pathways but due to it being a new technique, interpretation of the data was not completely understood [2]

1970’s - Detection of Dopamine In Vivo
- Studies carried out to measure the release and uptake of dopamine in mice, in vivo and in real-time [3]
- Use of carbon fiber microelectrodes in mice brains to determine dopamine concentrations and oxidation processes in the presence of interfering molecules [3]

Recent Studies
- The detection of dopamine has been difficult in the presence of ascorbic acid due to oxidation of both compounds occurring simultaneously. [4]
- New electrodes in development to be able to selectively detect dopamine in the presence of interfering species. [4]

Dopamine Redox Pathway

Methods

1. Electrode and solution preparation
- Gold working electrode
- Platinum counter electrode
- Ag/AgCl in 1 M AgCl reference electrode.
- 2 mg/ml Dopamine solution was prepared in water.
- Background electrolyte used was McIlvaine buffer, pH was adjusted with HCl and NaOH.
- The buffer containing 0.5 ml dopamine solution was deoxygenated under nitrogen for 10 minutes before measurements.

2. Cyclic Voltammetry (CV)
- Cyclic voltammetry (CV) measures the current resulting from the electron transfer process in the redox reaction of dopamine.
- Peak heights are proportional to the concentration of compounds in solution.
- A low scan rate was used for these CVs, as the follow up chemical reaction needs time to occur.
- A potential is applied linearly from an initial value to the first switching value.
- The potential then reverses into the opposite direction, applied with the same rate to the second switching value.
- Such potential pattern makes up a full CV cycle.

Results and discussions

- Potential was cycled from -0.7 V to 0.8 V in the positive direction, the initial and final potentials are both -0.1 V.
- Peaks A and B represent the redox couple dopamine and dopamine-o-quinone.
- Peaks C and D represent the redox couple leukodopaminochrome and dopaminochrome.

Chemical Reaction pH Threshold

- Initial CV measurement was taken at pH = 7.04, then in decreasing pH until the second (lower) redox peaks no longer showed up.
- The second redox peaks completely diminished at pH = 5.60, indicating that this was the pH threshold for the follow up chemical reaction.

Conclusions

- Linear relationship observed for the rate of cyclization as a function of pH
- Greatest rate of cyclization occurred at pH 7.8
  
  \[ y = -10.224x^2 + 26.27x - 23.56x + 7.5034 \]
  
- Each CV for each pH utilized the equation above to find \( k_f \)

Future Work

- Explore behavior of the follow up reaction of dopamine in basic pH ranges.
- Determine in detail the composition of the second redox couple.

Acknowledgements

This work was carried as part of the Integrated Lab Course (CHEM 410) during Spring 2019.

References