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# 論文 / 著書情報
# Article / Book Information

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| 題目(和文) | pH依存性の膨潤及び化学劣化挙動を有するアミン硬化エポキシ系材料の寿命予測に関する研究 |
| Title(English) | Toward the Service Life Estimation of Amine-cured Epoxy Materials: A Study on the pH Dependence of Swelling and Degradation Behavior |
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| Author(English) | Jonathon David Tanks |
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（博士課程）
Doctoral Program

# 論 文 要 約

THESIS OUTLINE

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| 系・コース：<br>Department of, Graduate major in | 応用化学 系 コース | 申請学位（専攻分野）：<br>Academic Degree Requested | 博士 ( 工学 )<br>Doctor of |
| 学生氏名：<br>Student's Name | Jonathon David Tanks | 指導教員（主）：<br>Academic Supervisor(main) | 久保内昌敏 |
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words )


Epoxy resins are widely used as lining materials and composite matrix resins for corrosion protection in a variety of industries, including automotive, marine, chemical, and civil. Due to the susceptibility of anhydride to hydrolyze in harsh environments, amine curing agents are a widely used alternative given their higher stability against water and also allow for curing at lower temperature compared to anhydride However, amine-cured epoxies are known to react with acids to form an amine salt at the crosslink sites, which can have detrimental effects on the epoxy resin. Although there is some discussion of this behavior in the literature, there is no clear understanding about the underlying mechanisms, particularly for the non-Fickian diffusion behavior. In the chemical industry, most vessels and pipes used for concentrated corrosives such as acids and hydroxides are made of glass FRP (GFRP). Due to the poor chemical-resistance of E-glass, a more durable fiber called C-glass was developed commercially for applications where E-glass is unsuitable; however, studies on E-glass composites are much more common than C-glass, meaning there should be more research regarding the long-term service life of C-glass/epoxy composites.

In this work, the pH-dependent swelling and degradation mechanisms due to acid penetration were studied in amine-cured epoxy resins, and these findings were applied to the service life prediction of epoxy resin and its composites, using primarily an experimental approach supported by theoretical analysis. The contents of this thesis is summarized as follows:

Chapter 1 provides a brief introduction to the topic of this thesis, as well as a review of the relevant literature and background information on basic concepts.

Chapter 2 reports the pH-dependent non-Fickian penetration behavior of acid solutions in poly(ether)amine/epoxy materials; results show that due to the basicity of tertiary amines ($pKa \approx 9.5$), alkaline solutions have negligible effect on diffusion behavior whereas acidic solutions correspond to distinctly concentration-dependent diffusion rates.

Chapter 3 extends the experimental and theoretical discussion from Chapter 2 to include the pH- and temperature-dependent swelling behavior, where the relationship between acid penetration and viscoelastic relaxation of the polymer is discussed and the definition of “penetrant concentration” is revisited.

Chapter 4 gives a detailed analysis on the relationship between the epoxy network structure and the equilibrium acid uptake, which culminates in the proposal of a degradation model based on crosslink density which does not use any fit parameters, and is applicable to a range of poly(ether)amine/epoxy systems.

Chapter 5 applies the results of Chapters 2 and 4 to a service-life prediction model for epoxy resins; a micro-scale network model is used to describe the global degraded state of the polymer based on the local degraded state which can be calculated using the model in Chapter 4.

Chapter 6 focuses on the long-term behavior of epoxy-based C-glass fiber laminates (GFRP) used in corrosive environments; the significant amount of swelling observed for amine-crosslinked epoxy (Chapter 3) is responsible for most of the degradation in GFRP, which was considered in the proposed service-life model.

Chapter 7 closes the thesis with a summary of all results and logical conclusions, as well as implications for future work and tangential applications. Applications of this work include life prediction and material design of epoxy lining materials and composite matrix resins in a variety of corrosive environments.



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