SP2 Report

On

Part 3: Epoxy Coating Specification

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1.0 Introduction

The effect of microbiologically induced corrosion is well established. Polymeric coatings are used to isolate the concrete pipes from the corrosion environment from sewers, thus providing a protective barrier. This aspect of the study examined the correlation between coating properties and coating performance in resisting acid permeation. The purpose of this are to developed two basic tools in selection of coatings:

i) Service life model based on accelerated tests

ii) Coating specifications

This part of the study will present the results for coating specification. The acid permeation results were based on accelerated testing achieved by immersing coupons of coatings in various acidic environments. The physical and chemical properties considered in this study include:

i. Chemical properties of coatings

LOI (wt%)	(loss of ignition) represents the percentage of polymeric component of the coating. This is established from XRF testing of the coating.
D(μm)	number mean particle size of the filler, established by microscopic examination of the coating
H	wetting property or hydrophilicity, measured from ratio of the peak height of the OH to benzene functional groups established by FTIR
F	Functionality- determines the crosslink density of the polymer
Td(°C)	Degradation temperature
Tg (°C)	Glass transition temperature

ii. Physical properties

t : coating thickness (mm)

The properties of the coatings and the acid permeation data have been presented in the SP2 report 3, Part 2 and 3. The results that will be presented here will only include the correlations of these parameters.

2.0 Results

Effect of LOI

LOI of loss on ignition represents the epoxy component that volatilised at 1050°C by XRF. This would reflect all the organic component or epoxy content and any residual moisture content of the epoxy.

Figure 1 shows that increasing the amount of epoxy in epoxy mortars reduces the rate of acid uptake. This applied to all the acids tested, citric, sulphuric and nitric acids and at all concentration tested. Reducing the epoxy content from 80 to 20 wt% increased the acid uptake by 600 to 4000% in the more corrosive conditions tested.

This property therefore constitutes an important aspect of the coating specification.

Effect of filler particle size

Filler including silica, clay, talc are incorporated into the epoxy matrix to provide a tortuous path of the acid. Essentially if the fillers are inert to the biogenic acids, then they form a barrier for the acid path requiring the acid to flow around the filler.

Figure 2 shows that reducing the particle size of the filler can significantly reduce the rate of acid permeation in all the acids tested and at all concentration.

The particle size and distribution of the filler constitute an important parameter in improving the resistance of the coating to acid permeation.

Hydrophilicity

The hydrophilicity measured the ratio of the hydrophilic functional groups (functional groups that loves water or polar chemicals) to benzene groups. In this study only the OH group was used. Whilst the hydrophobic functional groups would repel water, the hydrophilic components would attract acids.

Figure 3 shows that increasing the number of hydrophilic functional groups in the coatings appear to attract a greater quantity of acids that promote a greater rate of acid permeation.

Thus the presence of hydrophilic groups on the coating can have a significant impact on the ability of the coatings to resist acid permeation.

Degradation and glass transition temperature

The degradation and glass transition temperature reflects the crosslink density of polymeric coatings.

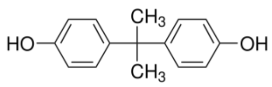
Figures 4 and 5 demonstrate a greater correlation of the acid uptake on the degradation temperature than glass transition temperature. These correlation shows that the higher degradation temperature appear provide greater resistance to acid permeation.

Functionality

The functionality is the number of sites that are available for reaction with curing reagents. In epoxy the functionality is the number of epoxide groups. The higher the number of functionality per molecular results in tighter and higher cross link density of the final resin. This is translated in greater chemical resistance. The three types of epoxy resins used for wastewater application are based on bisphenol A, bisphenol F and novolac and the corresponding functionality of these monomers are 1.9, 2.1 and 2.6-3.5.

Bisphenol A epoxy resin

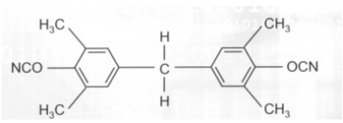
Bisphenol A results from the reaction of phenol and acetone.



The reaction of bisphenol A with epichlorohydrin forms diglycidylether bisphenol A resin or DGEBA. The molecular weight on DGEBA can be increased by adding more phenol.

Bisphenol F epoxy resin

Bisphenol F results from the reaction of phenol and formaldehyde.



The resulting phenolic monomer does not have the two methyl group present between the two benzene rings as found in bisphenol A. The reaction of bisphenol F with epichlorohydrin forms diglycidylether bisphenol F (DGEBF) resins. Because of the missing two methyl groups results in a higher proportion of trifunctional epoxide group increasing the functionality from 1.9 to 2.1, thus greater chemical resistance compared to bisphenol A resin.

Novolac epoxy resin

Novolac is a modification of Epoxy F resin achieved by adding greater quantities of phenol. This increases its functionality from 2.1 to 2.6-3.5 and thus its chemical resistance relative to both bisphenol A and bisphenol F resins.

Most coating formulations are based on a combination of these monomers resulting in different functional group. The effect of epoxy functionality is shown in Figure 6. As shown increasing the functionality and thus the cross link density of the coating can have significant retarding effect on acid permeation.

2.1 Effect of LOI

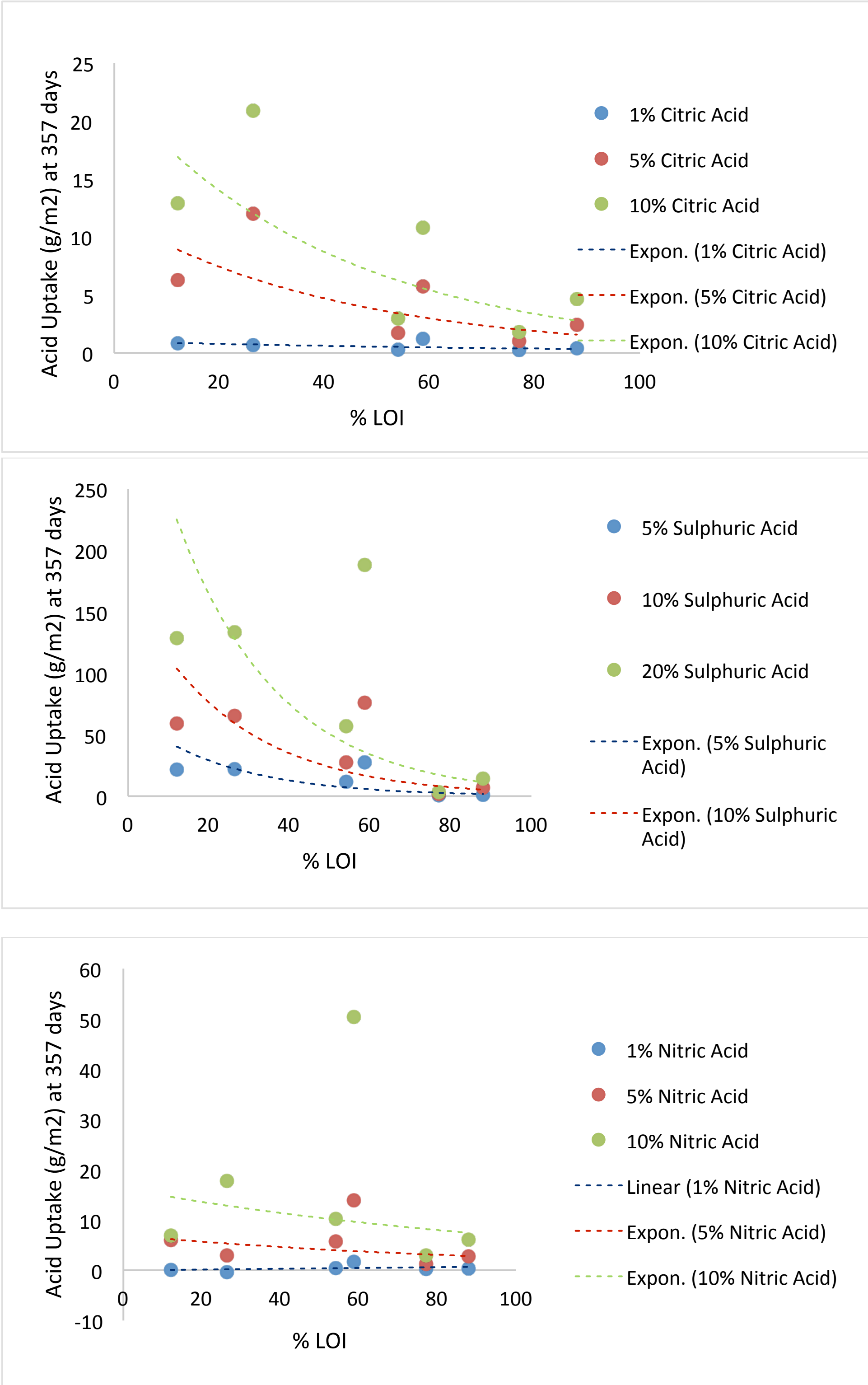


Figure 1. Effect of LOI on acid uptake at day 537 (coating thickness, 4-5 mm, acid immersion tests at 26°C).

2.2 Effect of filler particle size

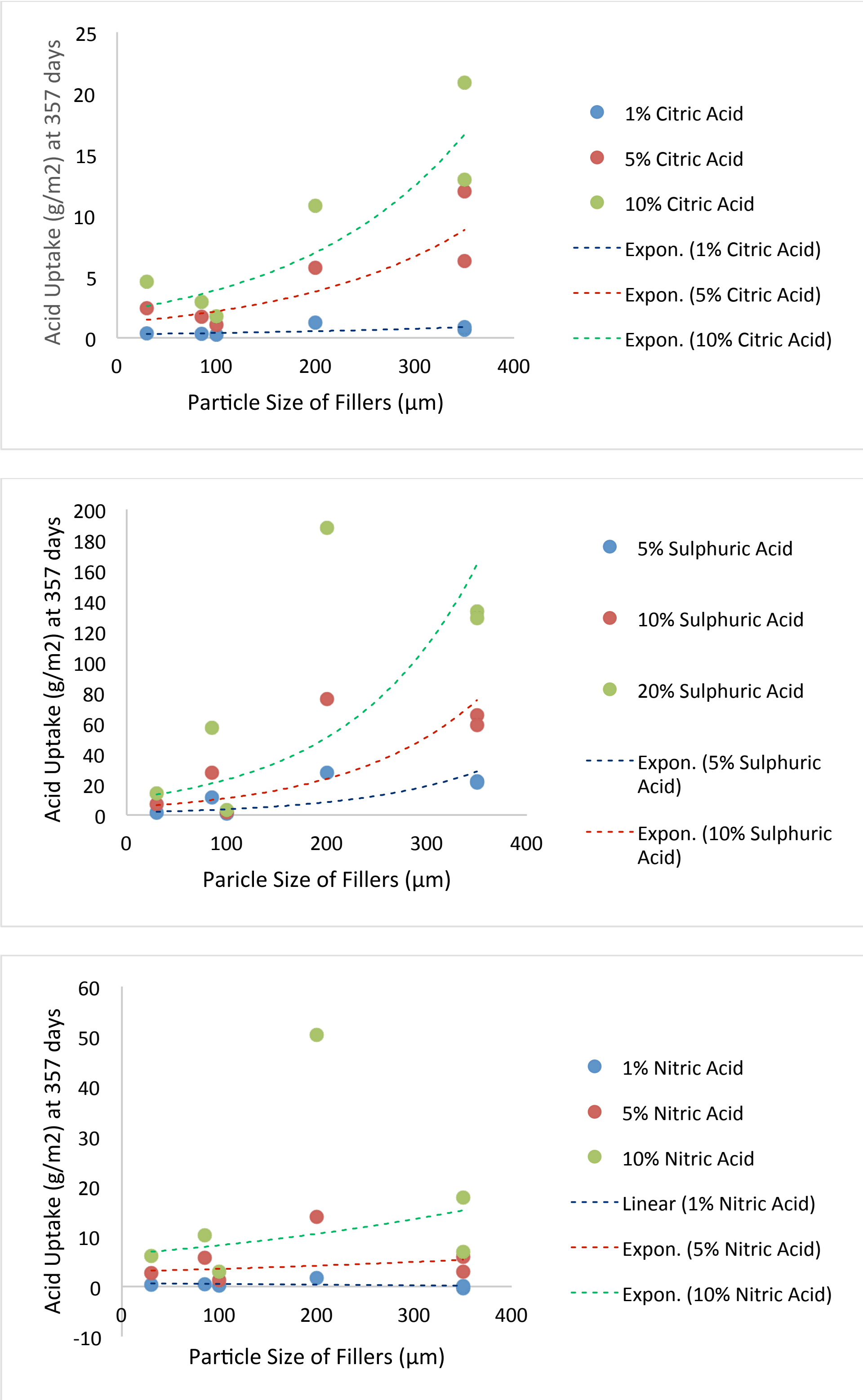


Figure 2. Effect of filler particle size on acid uptake at day 537 (coating thickness, 4-5 mm, acid immersion tests at 26°C).

2.3 Effect of hydrophilicity (wetting property)

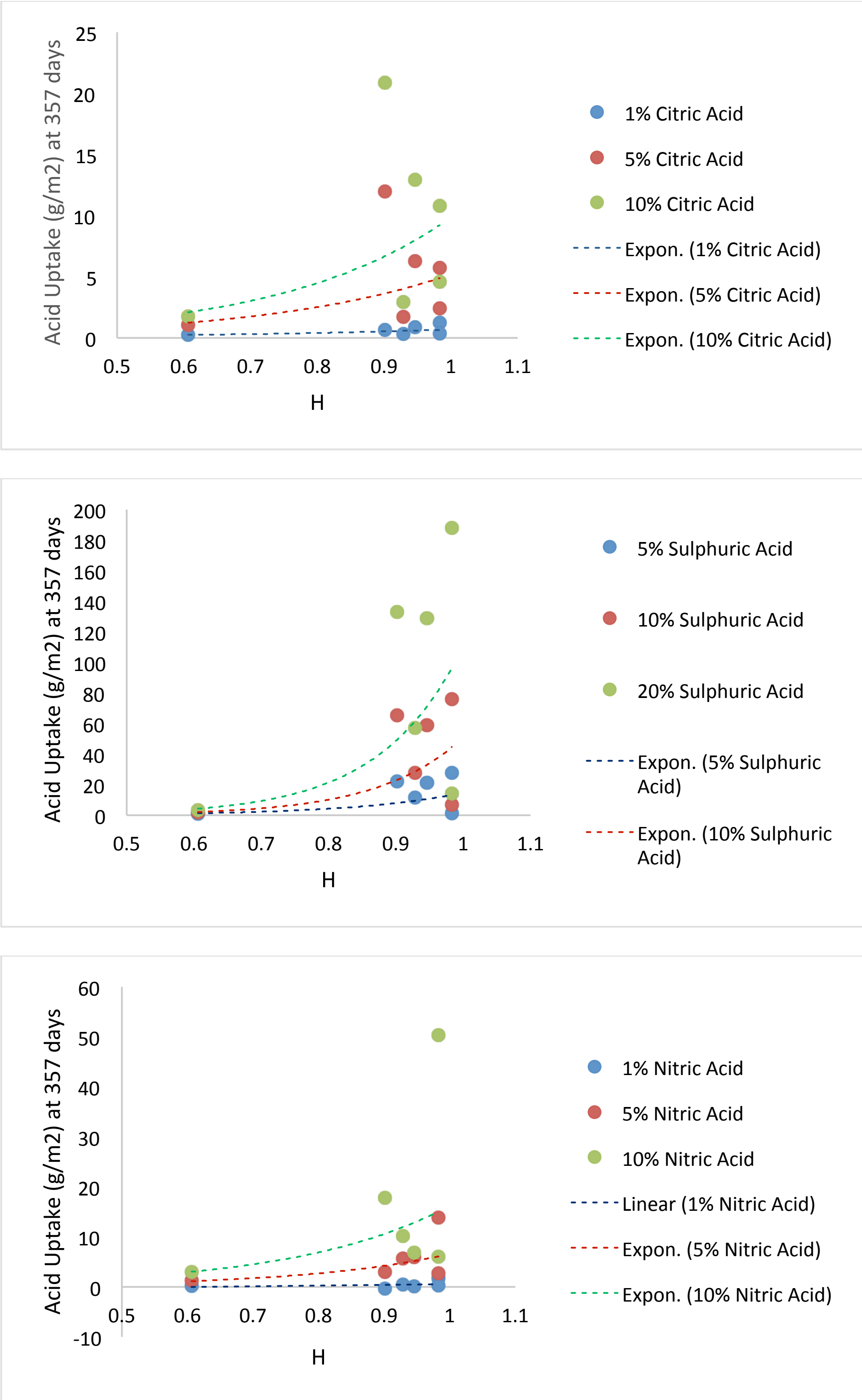


Figure 3. Effect of hydrophilicity (wetting property) on acid uptake at day 537 (coating thickness, 4-5 mm, acid immersion tests at 26°C).

2.4 Effect of degradation temperature

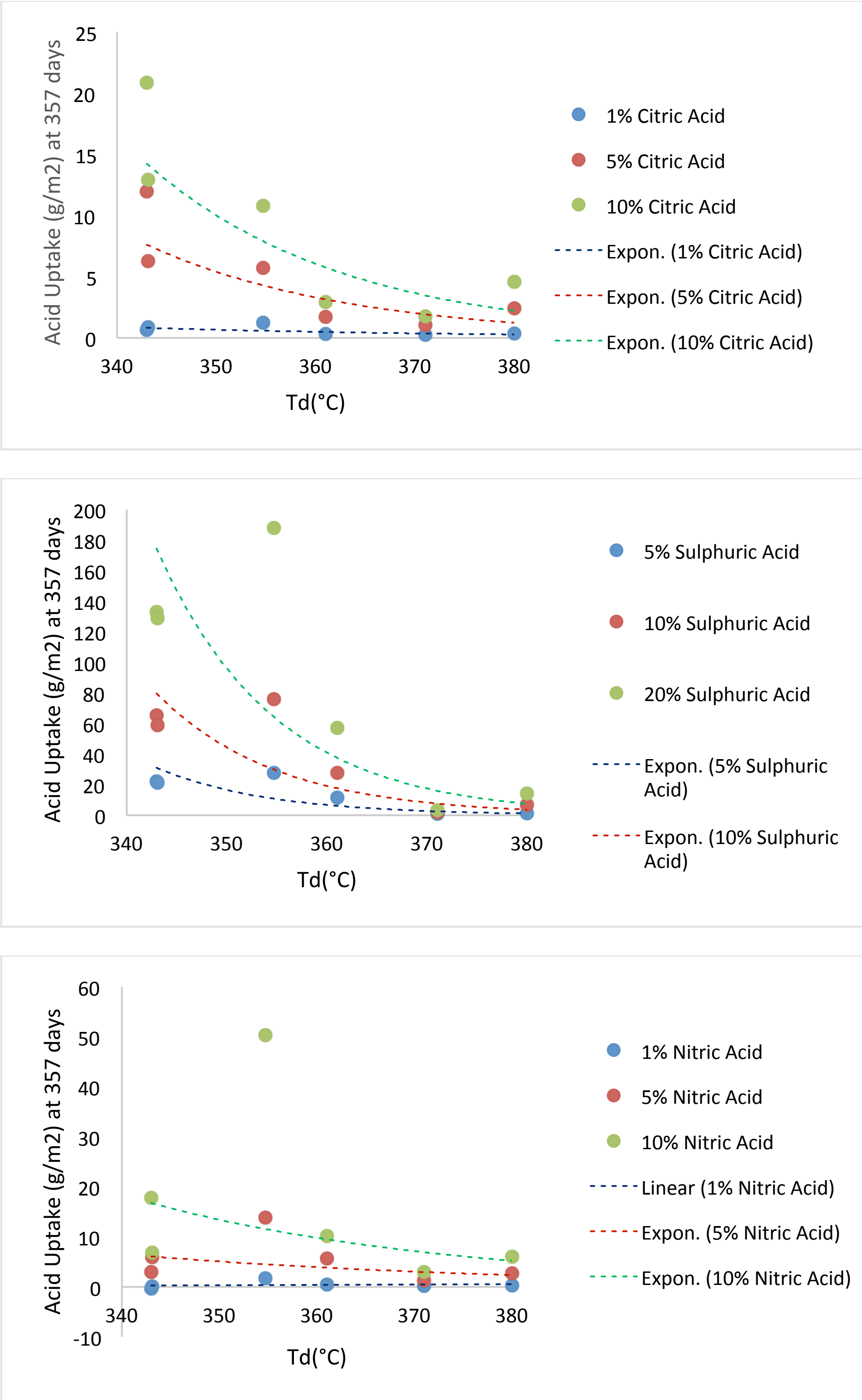


Figure 4. Effect of T_d(degradation temperature of epoxy) on acid uptake at day 537 (coating thickness, 4-5 mm, acid immersion tests at 26°C).

2.5 Effect of glass transition temperature

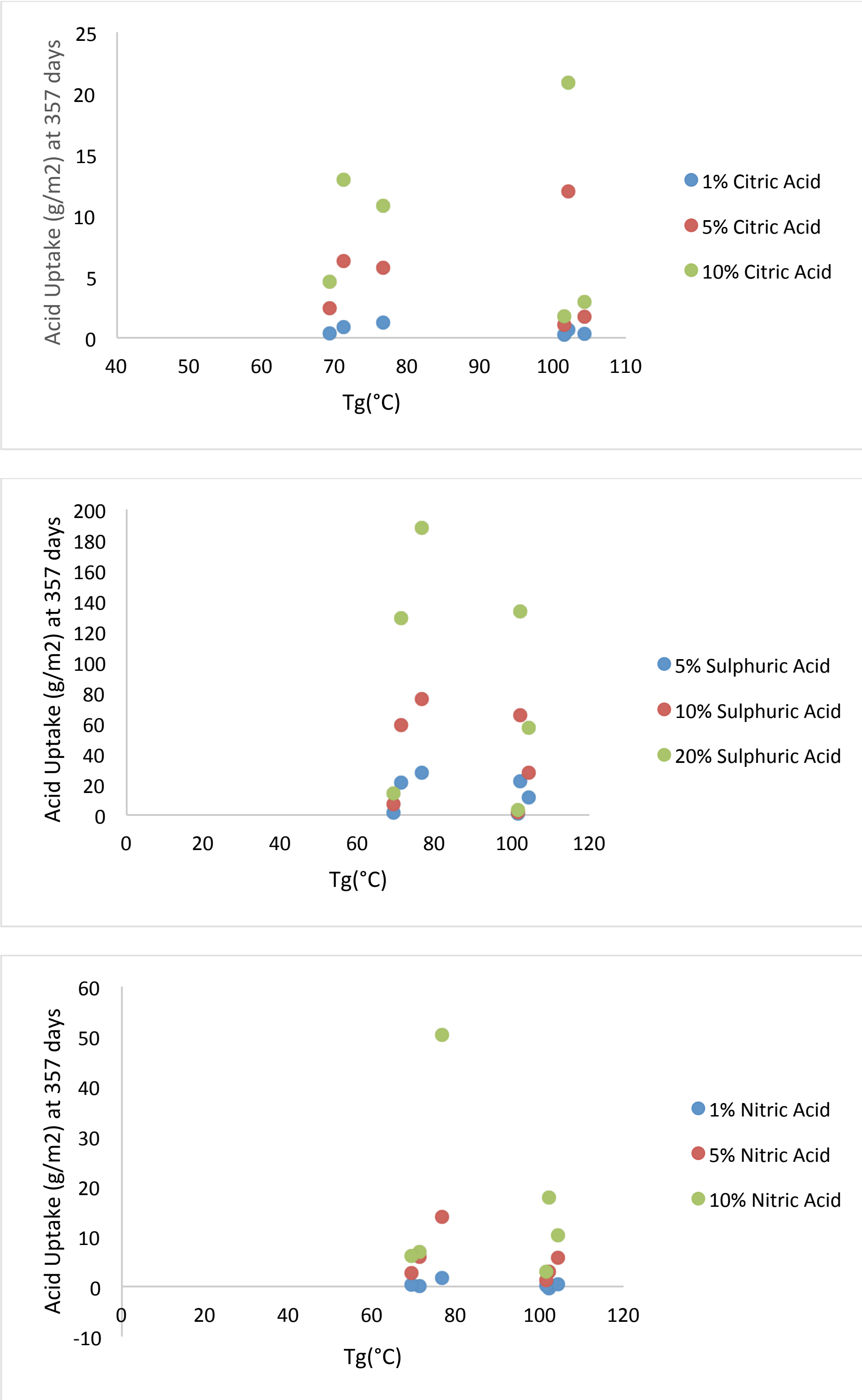


Figure 5. Effect of T_g(glass temperature of epoxy) on acid uptake at day 537 (coating thickness, 4-5 mm, acid immersion tests at 26°C).

2.6 Effect of epoxy functionality

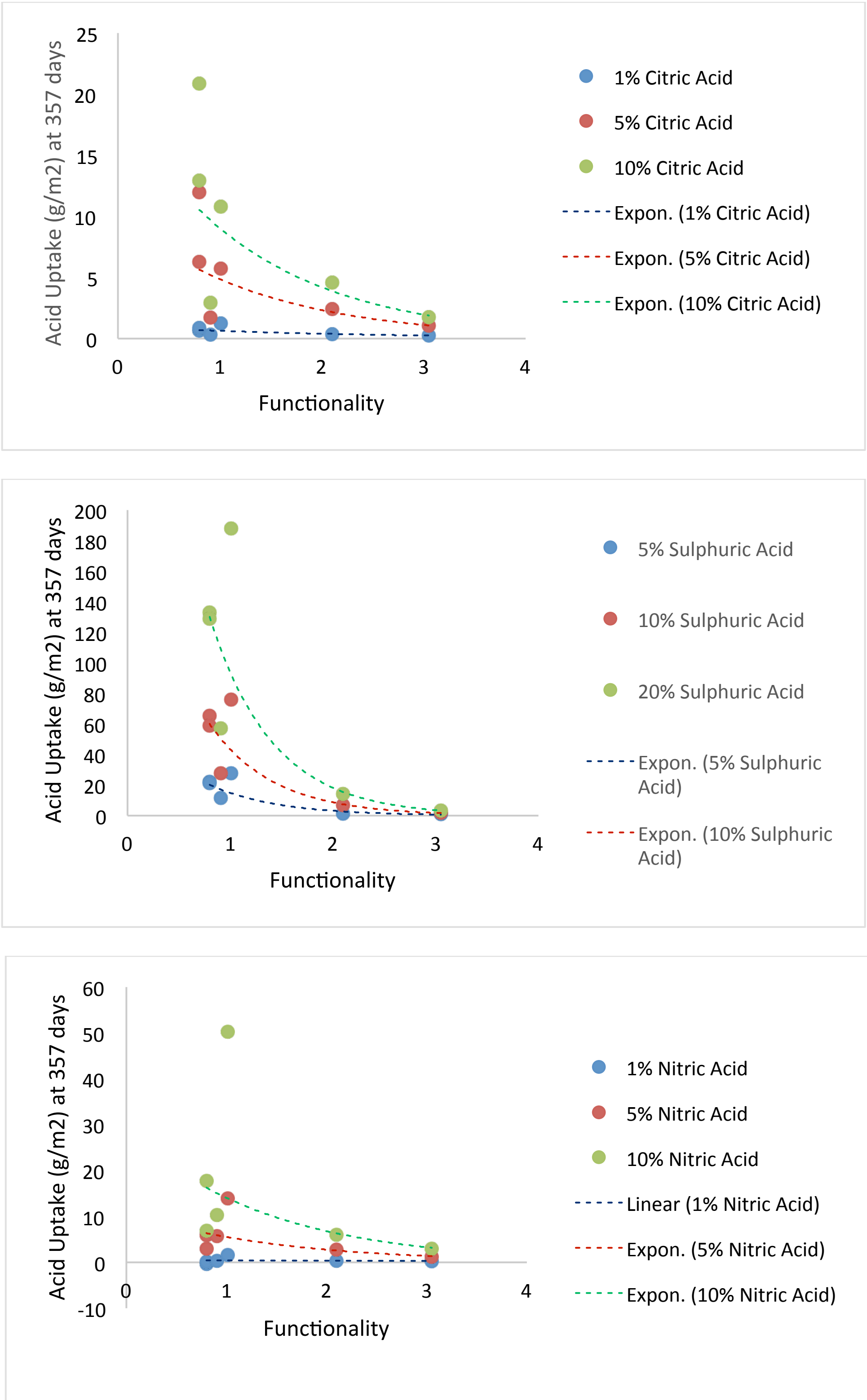


Figure 6. Effect of epoxy functionality on acid uptake at day 537 (coating thickness, 4-5 mm, acid immersion tests at 26°C).