CURE KINETICS OF EPON 828 CURED WITH TETA
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ABSTRACT

The curing reaction of diglycidyl ether of bisphenol A (DGEBA) with triethylene tetra amine (TETA) were studied with a differential scanning calorimeter (Perkin-Elmer DSC 6) under dynamic and isothermal conditions in the range 50-80 °C. A computerized data acquisition system was used to collect and process rate and integral heat of reaction data during reaction.

A mathematical kinetics model describing the reaction is proposed, the rate constants were determined at different temperature, and the heat of reaction was found to be 24.5-25 kcal/kmol. Good agreement between mathematical kinetics model and experimental data was found.

KEYWORDS
Cure kinetic, epoxy resin, DSC.
TETA مع Epon 828 دراسة تفاعل

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الخلاصة

تم في هذا البحث دراسة تفاعل أ نضاج Diglycidyl Eether of Tri Ethylene Tetra Amine (TETA) مع Bisphenol A (DGEBA) باستخدام جهاز المنح الفاصلي (Perkin-Elmer DSC 6 نوع DSC) تحت ظروف درجات الحرارة الثانية و المتغررة من (50-80 °C).

ثم استخدام الحاسب لجمع البيانات وتحليلها. اقترح نموذج رياضي لوصف التفاعل وحساب ثوابت معدلات التفاعل للدرجات الحرارية المختلفة و كانت حرارة التفاعل (24.5-25 kcal/kmol).

لقد وجد أن هناك تطابق بين النموذج الرياضي المقترح والنتائج المختبرية.
Mathematical Model of Autoclave Curing of Epoxy Resin Based Composite Materials

Adnan A. Abdul Razak  Najat J. Salah  Hassen Sh. Majdi

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Abstract
Polymer matrix composites using thermosetting resins as the matrix are increasingly finding use in several applications. Process modeling describing the governing curing has played an important role in improving the fundamental understanding and development of composite fabrication techniques. In present work, the thermokinetic involved in the autoclave curing of fiber-reinforced epoxy has been studied by means of a computer program, using the transient heat conduction equation coupled with kinetic equation, and the initial and boundary conditions. In the analysis the cure assembly is assumed to consist of a tool plate, composite laminate. The temperature distribution and the degree of reaction are obtained as a function of position and time.

Keywords: Mathematical model, curing, epoxy resin

Keywords: Mathematical model, curing, epoxy resin

الموليد الرياضي لعملية إضافة مكونات الأليوبسي في جهاز الأوتوليف

يشير استخدام المواد المكراتية الأليوبسي كمادة تكشكيل إلى أن الوضع الرياضي لعملية إضافة مواد الأليوبسي يتطلب كبيرة. ويجب للموليد الرياضي لعملية إضافة مواد الأليوبسي أن يكون على حساب حركة الجاذبية ودرجة الإضافة كدالة من الزمن (un steady state energy). ويفضل هذا الموليد على حل معدلة الطاقة (generated heat) مع إضافة حذف تمثل الحرارة المولدة (equation).

تستخدم الأليوبسي. ويعتمد الموليد الرياضي على موديل نتائجية التفاعل الأليوبسي الذي تم تMINGA باستعمال جهاز الأوتوليف.

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Study the Adhesion Force of Tubular Shaped Fiber Reinforced Composites

Hussein Ali Hamid AL-Abdly, Najat J. Saleh, Adnan A. AbdulRazak, and Hassen Sh. Majdi

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Abstract

In the present work tubular-shaped fiber reinforced composites were manufactured by using two types of resin epoxy (EP) and unsaturated polyester (UP), each was separately reinforced with glass, carbon and kevlar-49 fibers (filament and woven roving), hybrid reinforcement composites of these fibers were also prepared. The adhesion force test of the prepared specimens was carried out. These adhesion forces exhibited a peak value at a percent of hardener/resin (H/R) = 3% for UP matrix with all type of fiber arrangements while 30% was obtained for EP matrix. Such behavior was declined with increase in temperatures. Glass transition temperatures were determined from these measurements, and found to be 90°C for EP-glass and 83°C for UP-glass composites.

Keywords: Adhesion force, tubular shaped, composites
STUDY THE CREEP OF TUBULAR SHAPE FIBER REINFORCED COMPOSITES

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Assistant Prof.            Lecturer

Chem Eng. Dept.               University of Technology
Hussein Ali Hamid AL-Abdly   Hassen Sh. Majdi
Ministry of Science and Technology

ABSTRACT

In present work tubular – shaped fiber reinforced composites were manufactured by using two types of resins (Epoxy and unsaturated polyester) and separately reinforced with glass, carbon and kevlar-49 fibers (filament and woven roving), hybrid reinforcement composites of these fibers were also prepared. The fibers were wet wound on a mandrel using a purposely designed winding machine, developed by modifying an ordinary lathe, in winding angle of 55° for filament. A creep test was made of either the full tube or specimens taken from it. Creep was found to increase upon reinforcement in accordance to the rule of mixture and mainly decided by the type of single or hybridized fibers. The creep behavior, showed that the observed strain tends to appear much faster at higher temperature as compared with that exhibited at room temperate. The creep rate also found to be depending on fiber type, matrix type, and the fiber/matrix bonding. The creep energy calculated from experimental observations was found to exhibit highest value for hybridized reinforcement.

KEYWORDS

Creep, tubular shaped, composites
Diffusion of various liquids to tubular shaped fiber reinforced composites

Hussein Ali Hamid AL-Abdly*, Najat j. Salah**, Adnan A. AbdulRazak ***, and Hassen Sh. Majdi *

Abstract

In present work tubular –shaped fiber reinforced composites were manufactured by using two types of resins ( Epoxy and unsaturated polyester) and separately reinforced with glass, carbon and kevlar-49 fibers (filament and woven roving), hybrid reinforcement composites of these fibers were also prepared. The fibers were wet wound on a mandrel using a purposely designed winding machine, developed by modifying an ordinary lathe, in winding angle of 55° for filament. Various liquids were allowed to diffuse into the composite samples, where all composite samples were immersed in water, HCl (0.5N, IN) and NaOH (0.5N, 1N). The exhibited behaviors were mainly explained in accordance to Fick’s –law. However, there were few case of anomalous behavior observed.

The observed difference in diffusion rate for acidic and basic solutions may be explained in terms of different permeability of OH- and H+ ions in the composite samples. This permeability was also found to be affected by the debonding process which might be initiated by the liquid penetration. Diffusion coefficients were also deduced and their relatively higher values are indicative for some damage mechanism taking place in the composite and not the pure matrix. UP composite exhibited higher values than EP composite which suggest that higher damage has taken place in UP-composite.

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Study Diffusion of Water to Carbon Fiber/Epoxy Composite

Dr. Adnan A. Abdul Razak*

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Accepted on: 26/6/2008

Abstract
In present work moisture diffusion properties of the woven fabric carbon/epoxy laminates were determined using weight gain, experiments over a temperature range of 30°C to 60°C. The laminate–shaped fiber reinforced composites were manufactured by using epoxy resin (Epon 828) cured with TETA (tri ethylene tetra amine) reinforced with carbon fiber. The prepared Composite samples were immersed in water for several weeks and moisture content was measured. The diffusivity of the composite was found to obey the Arrhenius relation over the entire range of temperature. Analytical solution to Fick’s law is done by build up computer program in Matlab. Good agreement between experiment data and analytical solution of Fick’s Law.

Keywords: Composite, Diffusion, Laminate, Activation Energy.

دراسة التشاريه الماء لمادة متراكبة من الألياف الكاربون والإيبوكسي

الخلاصة
في البحث الحالي تم دراسة عملية التشاريه الماء في مواد متراكبة تمت تصنيعها من انتاج الإيبوكسي (إفين 828) المشコンテンツ والمادة القارية ثم غمر النساج في الماء لعدة أسابيع ودرجات حرارة تتراوح من 30 – 60 درجة ميلوية قدرة استيعاب الإلياف الألياف في النساج حسب قانون فيك (Ficks-law).

ال материалы والتحليلات

Nomenclature

\[
\begin{align*}
c & \quad \text{The concentration (mole/liter)} \\
P & \quad \text{Specific heat (J/kg°C)} \\
D & \quad \text{Diffusion coefficient (cm²/sec)} \\
E_d & \quad \text{Activation energy, kJ/mole} \\
h & \quad \text{Thickness of lam} \\
m & \quad \text{Thermal conductivity (kcal/h°C)} \\
M & \quad \text{Mass percentage of water absorbed (%)} \\
R & \quad \text{Gas constant, J/mole K} \\
t & \quad \text{Time (s)} \\
T & \quad \text{Temperature, °C} \\
\end{align*}
\]

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Electrical And Thermal Properties Of Epoxy Resin Filled With Carbon Black

Dr. Adnan A. Abdul Razak *, Dr. Najat J. Salah *, Waffa Abdul Kazem*

Received on 2/12/2008
Accepted on 4/6/2009

Abstract
Thermal and electrical conductivity of an insulating polymer can be achieved by dispersing conducting particles (e.g., metal, carbon black) in the polymer. The resulting materials are referred to as conducting polymer composites. Electrical and thermal properties of epoxy-carbon black composites were studied in this work. The weight fraction of the carbon blacks ranged from 0.0 up to 20 wt% with the epoxy resin. By discharging a high voltage through the composite it was found that the resistivity of the composite decreased. Epoxy-carbon black composites show significant differences from the neat epoxy resin measured in the frequency range. Conductivity percolation threshold was found when carbon blacks is added in the range of 1 and 2 wt%. It was found that the epoxy-carbon black composites have better thermal properties than the neat epoxy.

Keywords: Thermal conductivity, electrical conductivity, carbon black, epoxy

دراسة الخواص الحرارية والكهربيانية لرشت اللبوبوكسي المدعوم بمسحوق الكاربون

يمكن تحقيق التوصيل الحراري والكهربي لبوليمرات العازلة وذلك باستخدام ذرات مثل المعدن والكاربون الأسود. يشير هذا إلى أن المواد المتناهية ذات الصلة بمواد البهجة تؤدي إلى تحسين الخواص الحرارية والكهربيانية لرشت الأليوبكي المدعوم بمواد الكربون. عند محتوى مكونات تتراوح من 0 إلى 20٪، وجد عند أملاح كربونية عالية تحسين في الخواص الحرارية. وجد مسار التوصيل الشاذة عند 2-2٪، وجد مسار في حلول التوصيل الحراري لرشت الأليوبكي. المدعوم باسوس الكربون مقارنة بالأليوبكي عا غير المدعوم.

Nomenclature

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Across sectional area (mm²)</td>
</tr>
<tr>
<td>CB</td>
<td>Carbon black</td>
</tr>
<tr>
<td>v</td>
<td>Volume fraction of filler (%)</td>
</tr>
<tr>
<td>d</td>
<td>Thickness of the sample (mm)</td>
</tr>
<tr>
<td>Vc</td>
<td>Critical volume fraction</td>
</tr>
<tr>
<td>DC</td>
<td>Direct current</td>
</tr>
<tr>
<td>K</td>
<td>Thermal conductivity (W/m-K)</td>
</tr>
<tr>
<td>t</td>
<td>Temperature (°K)</td>
</tr>
<tr>
<td>ΔV</td>
<td>Critical volume fraction</td>
</tr>
<tr>
<td>I</td>
<td>Current (ampere)</td>
</tr>
<tr>
<td>σ</td>
<td>Electrical conductivity (s/cm)</td>
</tr>
<tr>
<td>R</td>
<td>Electrical resistivity (Ω.cm)</td>
</tr>
</tbody>
</table>

Greek Letters

* Corresponding authors
Mathematical Model For Autoclave Curing Of Unsaturated Polyester Based Composite Materials

Dr. Adnan A. Abdul Razak, Lecturer
Chem. Eng. Dept.-University of Technology

Abstract
Heat transfer process involved in the autoclave curing of fiber-reinforced thermosetting composites is investigated numerically. A model for the prediction of the temperature and the extent of the reaction across the laminate thickness during curing process in the autoclave of unsaturated polyester based composite has been developed. The governing equation for one dimensional heat transfer, and accounting for the heat generation due to the exothermic cure reaction in the composites had been used. It was found that the temperature at the central of the laminate increases up to the external imposed temperature, because of the thermal conductivity of the resin and fiber. The heat generated by the exothermic reaction of the resin is not adequately removed; the increase in the temperature at the center increases the resins rate reaction, which in turn generates more heat.

Key words: Mathematical model, Autoclave, Curing, Composite, Unsaturated polyester.

نماذج رياضية للإالتصاص بالابوتوكليف لرائحة البولي اتير الأشعة متراكبة

تم دراسة عملية انتقال الحرارة في جهاز الأوتوكليف لإضاح المواد المتراكبة باستخدام رائحة البولي أتير النقابي حيث تم أيجاد مولد رياضي يقوم بحساب درجات الحرارة ودرجة الإالتصاص ككل من الزمن و الموضع لعملية إضاح البولي أتير النقابي في جهاز الأوتوكليف وتمثل هذا المولد على حا مقدارا لطاقة (generated heat) مع إضافة حدو تم الحالة الموتادة (unsteady state energy equation )

نصاب البولي أتير النقابي. لقد وجد أن درجة الحرارة في منتصف طبقات المادة المتراكبة تزداد حتى تصل إلى درجة حرارة الإضاح. ونتيجة للحرارة الموتادة من تفاعلي الإالتصاص الباعث للحرارة وكون الموتاحة الحرارية للرائحة واللمعان والامكاني للازالة الحرارة بصورة حيدة لذلك سوف تتم الحرارة في منتصف الطبقات والذي سوف يؤثر المزيد من الحرارة.

Nomenclature
A Pre-exponential factor,

C_v Specific heat, J/g °C
Specific heat, J/°C

E Activation energy, KJ/mole

h Thickness of laminate, mm

H_r Total heat of reaction, J/g

K Reaction rate constant, s^-1

K Thermal conductivity, Kcal/h °C

m n Empirical exponents in the cure kinetic model

p Intercept in Eq. (15)

q Heat generated by the curing resin, J/g sec
IMPROVE THE PERFORMANCE OF EPOXY RESIN AND POLY (VINYL BUTYRAL) AS AN ALUMINUM METAL ADHESION

Saad R. Sultan† Najat J. Salah†† Adnan A. Abdul Razak***

Abstract:

The present work is mainly concerned with study the performance of epoxy resin which blended with poly (vinyl butyral) in order to be used as adhesive for aluminum metal. A different weight ratios of poly (vinyl butyral) was blended with epoxy resin (10-90 wt %) and these blends were cured at different conditions: time (10-60) minutes and temperature (100-200°C), different mechanical properties (shear stress, elongation and peeling stress) were carried out on the prepared samples.

Box – Wilson design method was adopted to find useful relationships between the three variables [(weight ratios and curing conditions (time & temperature)] with mechanical properties shear stress, elongation and peeling stress, it was found that the best adhesive properties of the prepared sample (i.e. best mechanical properties) obtained with the weight ratio of (40 wt% epoxy resin and (60) wt% poly (vinyl butyral) while the best curing condition obtained at a temperature of 160°C for (30) min.

المستخلص:

البحث الحالي يدرس تحسين أداء راتنج البيروكسي بعد خلطه مع بولي فينيل بيتورال وذلك لاستخدامه لغرض نسق معين للألمنيوم، تم استخدام نسبة ووزن مختلفة من راتنج البيروكسي مع بولي فينيل بيتورال تتراوح بين (10-90)٪ كما وجودت نسبة وزنية وذهناً المتناقصة ثم انتجاجها في ضره مختلف من درجات حرارة وزمن حيث تم استخدام درجات حرارة إضافية تتراوح بين (100-200) درجة مسليزية وزمن إضافي يتراوح بين (10-60) دقيقة، بعد ذلك تم قياس النسب الميكانيكية (جهد القص، الاستطالة وجهد التثبيت) للتماوج المحضر.

تم استخدام تقنية Box – Wilson design من أجل إيجاد علاقات تربط المتغيرات الثلاثة (النسبة الوزنية المختلفة، درجة حرارة إضافية وزمن إضافي) مع فحص الخواص الميكانيكية المختلفة وهي جهد القص، الاستطالة وجهد التثبيت حيث وجد أن أحسن خواص المثابرة والفاضل خواص ميكانيكية تم الحصول عليها عند النسبة الوزنية 40٪ من راتنج البيروكسي و60٪ من بولي فينيل بيتورال بينما أحسن درجة حرارة إضافية كانت هي 160 درجة مسليزية وعهد زمن إضافي قدره 30 دقيقة.

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MODELING OF THE CURE OF EPOXY BASED COMPOSITE, HEATED AT CONSTANT TEMPERATURE IN CYLINDRICAL MOULD

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ABSTRACT

The heat transfer process involved in the curing of fiber-reinforced thermosetting composites is investigated numerically. This composite is made of woven fiber and resin and placed in a cylindrical mould. The governing equation for one dimensional heat transfer, and accounting for the heat generation due to the exothermic cure reaction in the composites had been used. A finite element method is developed to solve the mathematical model problems for composites manufacturing. The solution of the complete mathematical system gives, both, the temperature and the degree of reaction as functions of time and position. It was found that the temperature at the central of the sample increases up to the external imposed temperature, because of the thermal conductivity of the resin and fiber. The heat generated by the exothermic reaction of the resin is not adequately removed; the increase in the temperature at the center increases the resins rate reaction, which in turn generates more heat.

Keywords : Mathematical model, curing, epoxy resin, cylindrical mould