ISETC2025

UNIVERSITI TEKNOLOGI MARA

ISETC2025

2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

ORGANIZED BY:
FACULTY OF APPLIED SCIENCES
UNIVERSITI TEKNOLOGI MARA
PERAK BRANCH, TAPAH CAMPUS
MALAYSIA

CO-ORGANIZED BY:

三重大学
MIE UNIVERSITY

2nd International Science, Engineering and Technology Colloquium

(ISETC 2025)

Faculty of Applied Sciences,
Universiti Teknologi MARA,
Perak Branch, Tapah Campus,
35400 Tapah Road, Perak, Malaysia.

Colloquium date: 9th July 2025
Publication date: 9th September 2025

Proceedings of Extended Abstracts

EDITORS

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

e-ISBN: 978-629-97630-5-5

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Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

THERMAL BEHAVIOR OF UV-CURED ACRYLATED WASTE COOKING OIL COATINGS: COMPARATIVE EFFECTS OF CURING TIME AND PHOTOINITIATOR SYSTEMS

Munirah Onn[1*], Saiyidah Nafisah Hashim[2], Mat Uzir Wahit[3], Mazleenda Mazni[4]

[1]Faculty of Applied Sciences, UiTM Cawangan Johor, Kampus Pasir Gudang, 81750, Masai, Johor, Malaysia
[2]Faculty of Applied Sciences, UiTM Cawangan Perak, Kampus Tapah, Tapah Road, 35400 Tapah Road, Perak, Malaysia
[1,3]Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia
[4]Faculty of Mechanical Engineering, UiTM Cawangan Johor, Kampus Pasir Gudang, 81750, Masai, Johor, Malaysia

**Corresponding author: munirah591@uitm.edu.my*

Abstract: This study investigates the thermal behavior of UV-LED-cured acrylated waste cooking oil (AWCO) coatings, analyzing the effects of curing time (5, 10, 15, and 20 minutes) on crosslinking and stability. Coatings were polymerized under a 365-nm UV-LED using free radical and cationic photoinitiators. Thermogravimetric analysis (TGA) revealed distinct degradation profiles: the free radical system achieved peak initial decomposition at 362.2 °C (10 min), while ash content peaked at 6.0% (15 min), indicating optimal crosslinking at intermediate times. In contrast, the cationic system exhibited superior thermal stability (initial decomposition: 386.3 °C at 5 min) and progressive ash content increase (5.8% at 20 min), attributed to its oxygen-insensitive living polymerization. Differential scanning calorimetry (DSC) confirmed complete curing within 5 minutes for cationic systems, evidenced by the disappearance of exothermic monomer peaks. These results demonstrate that 10-minute UV-LED curing optimizes free radical coatings, whereas 5 minutes suffice for cationic systems, balancing efficiency and thermal performance. The study highlights the critical role of photoinitiator chemistry and curing duration in upcycling waste oils into robust coatings.

Keywords: *UV-LED curing, waste cooking oil coatings, free radical and cationic photoinitiator, thermogravimetric analysis (TGA), Differential scanning calorimetry (DSC)*

INTRODUCTION

Waste cooking oil (WCO), a byproduct of food processing, presents an attractive feedstock for polymer synthesis, offering both economic and ecological benefits by repurposing waste into value-added products (Onn et al., 2024). Ultraviolet (UV) curing technology has emerged as an efficient method for producing coatings with rapid curing rates, low energy consumption, and minimal volatile organic compound (VOC) emissions (Decker, 2001). UV-curable coatings based on acrylated waste cooking oil (AWCO) are typically formulated with photoinitiators, which play a crucial role in initiating the polymerization process upon exposure to UV light (Fouassier & Rabek, 2012). The selection of photoinitiator systems, along with curing parameters such as irradiation time, significantly influences the thermal stability and mechanical properties of the resulting coatings (Choi et al., 2025). Understanding the thermal behavior of UV-cured acrylated WCO coatings is essential for assessing their suitability in high-temperature applications. Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) are commonly employed to evaluate the thermal degradation patterns and glass transition temperatures of cured films (Pascault et al., 2002). Previous studies have demonstrated that curing conditions and photoinitiator chemistry can affect crosslinking density, which in turn influences thermal stability (Sangermano et al., 2007). However, a comparative study on the effects of different photoinitiator systems and curing times on the thermal properties of AWCO coatings remains limited. This study investigates the thermal behavior of UV-cured AWCO coatings, focusing on the comparative effects of curing time and photoinitiator systems. The findings aim to provide insights into optimizing UV-curing parameters for improved thermal performance, contributing to the development of sustainable coating materials.

MATERIALS AND METHODS

AWCO resins were mixed with 35% trimethylolpropane triacrylate (TMPTA) monomer and 3% photoinitiator (free radical: Irgacure TPO or cationic: Irgacure 250) using magnetic stirrer for 5 minutes. The mixtures were applied onto 2 mm silicone molds and PMMA plastic and cured under UV LED light at 85% intensity and temperature at 30 °C for 5, 10, 15, or 20 minutes. Thermal stability was evaluated via TGA (TA Q600) under N_2 (30–650 °C, 10 °C/min), recording weight loss (TGA) and decomposition rates (DTG). Glass transition (Tg), melting (Tm), and crystallization (Tc) temperatures were analyzed by DSC (TA DSC25) using TRIOS software. Samples were heated (-30 to 300 °C, 10 °C/min, N_2), cooled, and reheated to assess thermal transitions.

RESULTS AND DISCUSSION

From the DSC test, both photoinitiator achieved optimal thermal properties at just 5 minutes of curing, as evidenced from Figure 1 (a) and (b) below. With an enthalpy of 40.7 J/g, the uncured AWCO coating shows a notable exothermic peak at 50.4 °C, suggesting the existence of unreacted acrylate functional groups. The heat released during polymerization is represented by this peak, indicating that heating causes the prepolymer to cure. In every instance, the exothermic peak at 50.4 °C vanishes after 5, 10, 15, and 20 minutes of UV-LED curing. This peak's absence indicates that the polymerization process is finished and that the cured coating has no leftover monomer.

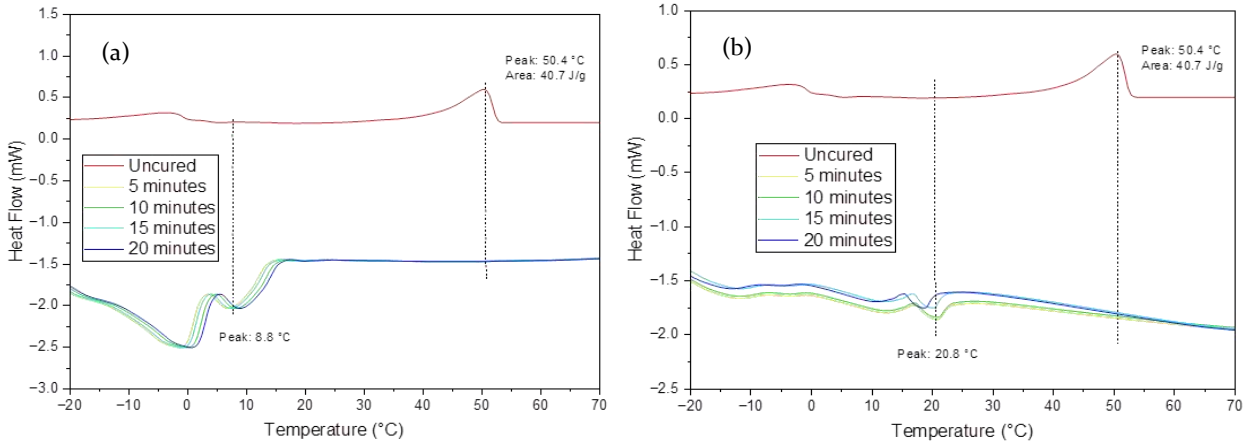


Figure 1. DSC heating curve for uncured and cured coating at 5, 10, 15 and 20 minutes curing time using (a) free radical and (b) cationic photoinitiator

Figure 2 and 3 graph revealed distinct differences between free radical and cationic photoinitiation systems for AWCO coatings. For the free radical system, initial decomposition temperature increased from 343.7°C at 5 minutes to a peak of 362.2°C at 10 minutes before declining with longer curing times, suggesting 10 minutes as the optimal curing duration. This system exhibited a single degradation phase between 411.3-418.1°C and maximum ash content (6.0%) at 15 minutes, indicating relatively simple degradation behavior. In contrast, the cationic system demonstrated superior thermal stability with initial decomposition starting at 386.3°C (5 minutes) and maintaining higher values than the free radical system across all curing times, though it showed gradual decline with extended exposure. The cationic system's two distinct degradation peaks (407.9-413.4°C and 470.5-477.1°C) reflected its more complex crosslinked structure, while its ash content increased steadily to 5.8% at 20 minutes, confirming progressive network formation. Nowak et al. (2018) attributed this to cationic polymerization's unimolecular termination versus free radical's bimolecular process. Free radical systems, susceptible to oxygen inhibition, form simpler networks through rapid radical termination, while cationic systems benefit from living polymerization that continues after irradiation, creating denser networks.

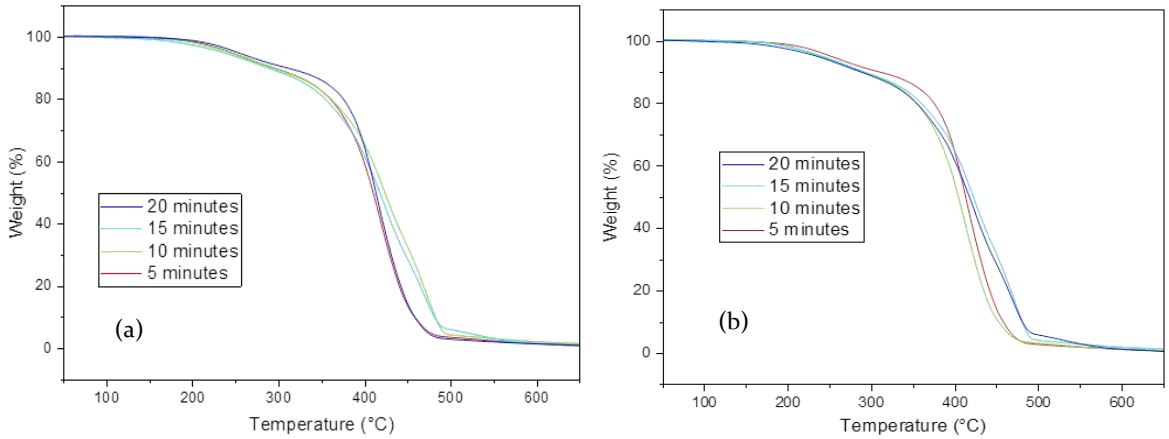


Figure 2. TGA result at 5, 10, 15 and 20 minutes for (a) free radical and (b) cationic photoinitiator

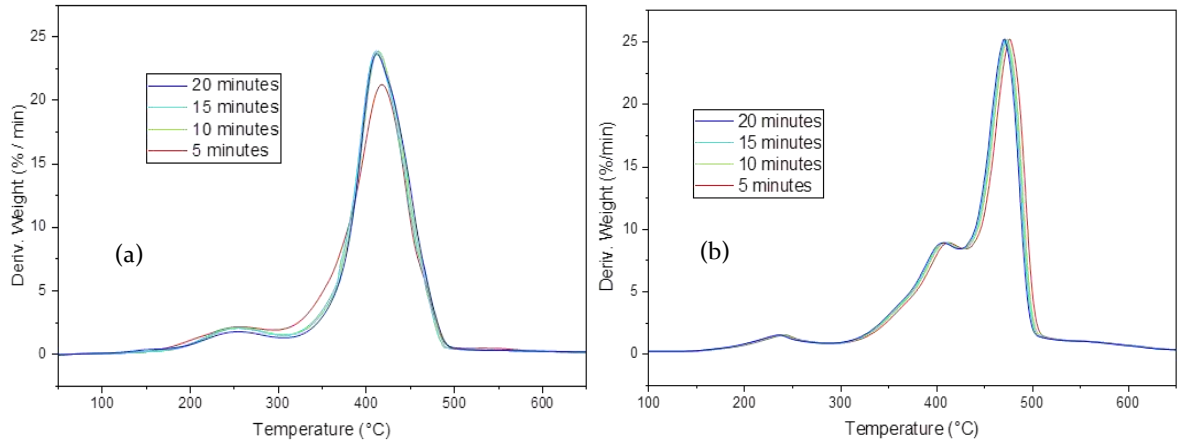


Figure 3. DTG result at 5,10,15 and 20 minutes for (a) free radical and (b) cationic photoinitiator

CONCLUSIONS

DSC analysis confirms the completion of polymerization at 5 minutes, as evidenced by the absence of residual monomer peaks, indicating full curing. TGA results demonstrate that while free radical systems achieve optimal crosslinking and thermal stability at 10 minutes, cationic systems reach peak performance at just 5 minutes, exhibiting superior thermal resistance and network integrity. The minimal variation in thermal degradation across curing durations suggests that 5 minutes may suffice for both systems, though cationic formulations consistently exhibit enhanced thermal stability and crosslinking efficiency. For future studies, the relationship between curing kinetics and long-term mechanical properties should be investigated to further optimize formulation performance under operational conditions.

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Sekian, terima kasih.

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