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The 1st International Symposium of Indonesian Chemical Engineering (ISIChem) 2018

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Preface: The 1st International Symposium of Indonesian Chemical Engineering (ISICChem) 2018

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*Editor of ISICChem 2018

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This proceedings volume contains selected articles from the “1st International Symposium of Indonesian Chemical Engineering (ISICChem) 2018” held in Kryad Bumi Minang Hotel, West Sumatra, Indonesia from October 4-6, 2018, that has been peer reviewed.

Despite the fact that this is only our first international symposium of Indonesian Chemical Engineers, and the sixth for the national one, we are so honored to announce that this year we have abundance of enthusiastic participants from five different countries participating in the conference. In the October 4-6, 2018, 250 research papers have been presented in the ISICChem, covering eleven research areas, such as: Biochemical Engineering, Catalyst and Reaction Engineering, Waste Water Treatment Technology, Renewable Energy Technology, Nano Materials and Nanotechnologies, System Engineering Process, Thermodynamics and Supercritical Technology, Separation and Purification Technology, Food and Pharmaceutical Technology, Chemical Engineering Management, and Chemical Engineering Education. We are also delighted to announce that the selected papers will be published in IOP Conference Series: Materials Science and Engineering.

We would like to take this opportunity to acknowledge the incredible support from our main sponsors: STARBORN (PT. Luas Birus Utama), PT. Semen Indonesia, BPJS Ketenagakerjaan, PT. Pupuk Indonesia, and PTPN X. I would also like to express my sincere gratitude to all the steering and organizing committees from Institut Teknologi Sepuluh Nopember (ITS) and Universitas Bung Hatta (UBH) and all the parties for the hard work and tremendous effort they have dedicated to make this event successful.

Alongside our seminars, another important agenda of the national chemical engineers is also taking place at the same time, namely the Annual General Meeting (Musyawarah Nasional) of the Indonesian Chemical Engineering Education Association (APTEKIM).

We would like to thank again the speakers, presenters, participants, and sponsors, who were responsible for the success of the seminar, and look forward to the second edition of the ISICChem seminar.

Hakun Wirawasista Aparamarta, PhD

Chairman of ISICChem 2018



The Editors of the Work shall be:

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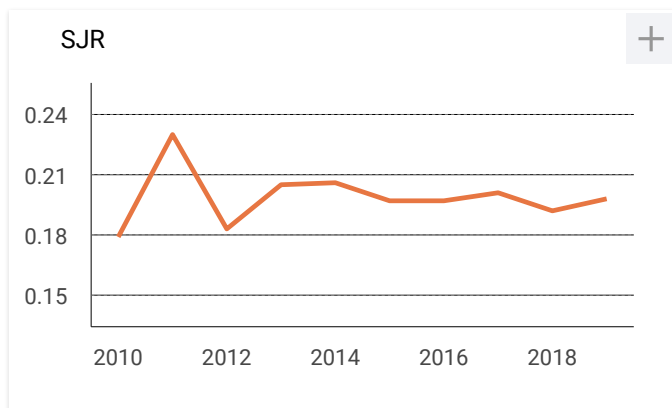
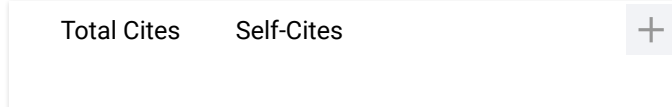
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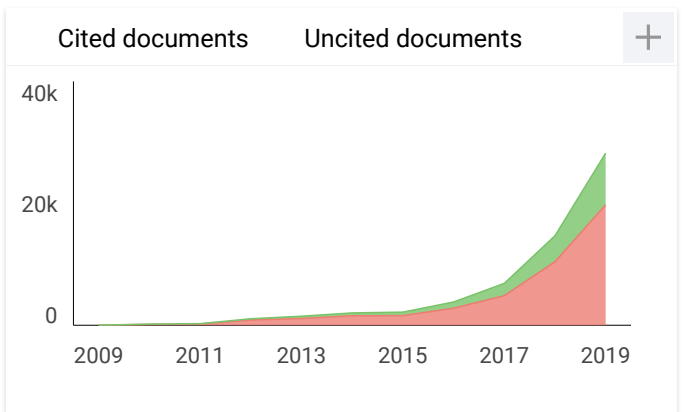
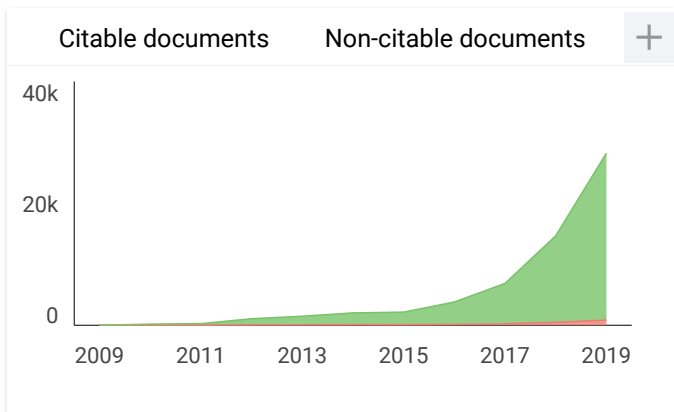
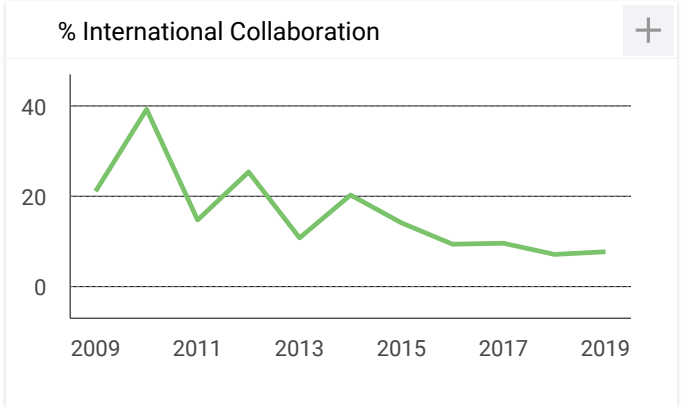
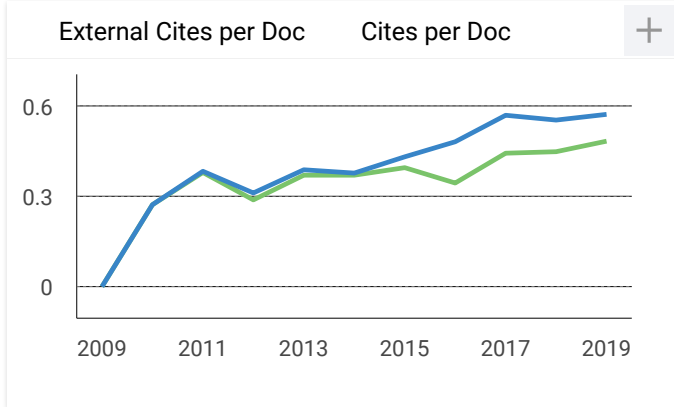
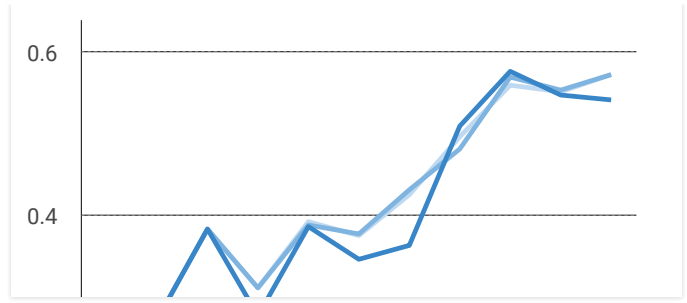
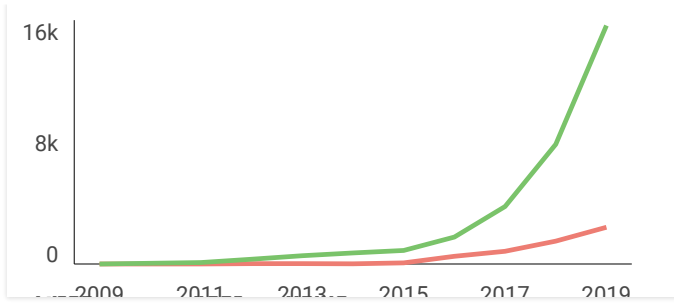
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Country	United Kingdom - IIR SIR Ranking of United Kingdom
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Publisher	IOP Publishing Ltd.
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K **KOVENDAN** 4 weeks ago

Dose the IOP conference series covers in scopus database or not.

reply



Melanie Ortiz 3 weeks ago

SCImago Team

Dear Kovendan,

Thank you very much for your comment.

All the metadata have been provided by Scopus /Elsevier in their last update sent to SCImago, including the Coverage's period data. The SJR for 2019 was released on 11 June 2020. We suggest you consult the Scopus database directly to see the current index status as SJR is a static image of Scopus, which is changing every day.

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Best Regards, SCImago Team

R **Rafael** 1 month ago

No se visualiza el cuartil, cual es el motivo?

reply



Melanie Ortiz 1 month ago

SCImago Team

Dear Rafael,

Thank you for contacting us. Please see comments below.

Best Regards, SCImago Team

V **Vo Anh Tuan** 1 month ago

Dear Melanie , Elena and SCImago team

Can you please let me know Q1/ Q2:/ Q3 or Q4 Classification as the journal IOP Conference Series : Materials Science and Engineering , with the Volume published as the link below:

<https://iopscience.iop.org/volume/1757-899X/869>

Thank you so much for your Promp reply

Warmest regards

Võ Anh Tuấn

University of Architecture of HO CHI MINH CITY, VIETNAM

Tel: 84908226165

196 Pasteur , District 3, HCMC, Vietnam

reply



Melanie Ortiz 1 month ago

SCImago Team

Dear Vo Anh Tuan,

Thank you for contacting us. We calculate the SJR data for all the publication's types, but the Quartile's data are only calculated for Journals and Book Series.

Best regards, SCImago Team

P **ptnabeel** 2 months ago

I was looking for a template to publish my paper in IOP conference series: Material Science and Engineering.

reply



Melanie Ortiz 2 months ago

SCImago Team

Dear Sir/Madam,

thank you for contacting us.

We suggest you visit the journal's homepage (See submission/author guidelines) or contact the journal's editorial staff , so they could inform you more deeply.

Best Regards, SCImago Team

H **Haydar Al-Ethari** 2 months ago

I hope this message finds you very well

I have two papers published in the IOP Conference Series: Materials Science and Engineering, Volume 881, 3rd International Conference on Sustainable Engineering Techniques (ICSET 2020) 15 April 2020, Baghdad, Iraq, but I did not find them in my id author profile in scopus and could not add them manually. Is there any problem with this publication/conference/journal? (may be out of scopus). The online publication was at 1/7/2020.

Best Regards

reply

S **Saran** 1 month ago

Hi.is there any problem in adding to scopus author profile?



Melanie Ortiz 1 month ago

SCImago Team

Dear Saran,

thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you contact Scopus support:

https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus

Best Regards, SCImago Team



Melanie Ortiz 2 months ago

SCImago Team

Dear Haydar,

thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you contact Scopus support:

https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus/

Best Regards, SCImago Team

A **AL-Kurdhani J. M. H.** 3 months ago

Hello

Dear Elena,

I want to know what is the value of impact factor of 2019 for useful all MSC. or/and pH.D. students by publishing in these journals and my students need the Q1 or Q2 in SJR with Scopus Q-ranking to graduation.

Thank you so much.

Best Regards,

reply



Melanie Ortiz 3 months ago

SCImago Team

Dear AL-Kurdhani,

Thank you for contacting us. Could you please tell us which particular journal you are referring to?

Best Regards, SCImago Team

V **Virat Khanna** 3 months ago

Can you please tell, how much time does IOP conference series take to publish the proceeding of the conference after the conference date.

reply



Melanie Ortiz 3 months ago

SCImago Team

Dear Virat,
thank you for contacting us.
Unfortunately, we cannot help you with your request, we suggest you contact the editorial staff , so they could inform you more deeply.
Best Regards, SCImago Team

S **syafriyudin** 5 months ago

is The journal IOP Conference Series: Materials Science and Engineering in the scopus index

reply



Melanie Ortiz 5 months ago

SCImago Team

Dear Syafriyudin,
Thank you very much for your comment.
All the metadata have been provided by Scopus /Elsevier in their last update sent to SCImago, including the Coverage's period data. The SJR for 2019 was updated on June 2020, 11. We suggest you consult the Scopus database directly to see the current index status as SJR is a static image of Scopus, which is changing every day.
Best Regards, SCImago Team

F **Fouad Fadhil Al-Qaim** 5 months ago

Dear Sir/Madam

May I know this Journal whether Q1, Q2,Q3 or Q4? Actually, there is no any quarter reported here.

Thank you

reply



Melanie Ortiz 5 months ago

SCImago Team

Dear Fouad,

Thank you for contacting us. We calculate the SJR data for all the publication's types, but the Quartile's data are only calculated for Journals.

Best regards, SCImago Team

R **Raj kamal** 5 months ago

IOP is whether scopus indexed

reply



Melanie Ortiz 5 months ago

SCImago Team

Dear Raj,

Thank you very much for your comment.

All the metadata have been provided by Scopus /Elsevier in their last update sent to SCImago, including the Coverage's period data. The SJR for 2019 was updated on June 2020, 11. We suggest you consult the Scopus database directly to see the current index status as SJR is a static image of Scopus, which is changing every day.

Best Regards, SCImago Team

R **ramanathan venkatachalam** 5 months ago

What is impact factor of IOP Conf. Series: Materials Science and Engineering

reply



Melanie Ortiz 5 months ago

SCImago Team

Dear Ramanathan, thank you very much for your comment.

SCImago Journal and Country Rank uses Scopus data, our impact indicator is the SJR.

Check out our web to localize the journal. We suggest you consult the Journal Citation Report for other indicators (like Impact Factor) with a Web of Science data source. Best Regards, SCImago Team

A **Abbas Al-Hdabi** 7 months ago

Dear Elena

I hope that you are very well and will be safe within Corona virus crises.

Please let me know when you issue the new journal classification i.e. Q1, q2 ... and what is your strategy for your update.

My query is a general one not regarding IOP publications.

Kind regards and stay safe

Abbas

reply



Melanie Ortiz 7 months ago

SCImago Team

Dear Abbas,

Thank you for contacting us. Our data come from Scopus, they annually send us an update of the data. This update is sent to us around April / May every year. Thus, the indicators for 2019 will be available in June 2020. Best Regards, SCImago Team

B **Boumediene sadoun** 8 months ago

Hello

I want to know what is the value of impact factor of 2019.

Also, is the nature of publishing in this journal considered as an article or a processing?

In addition to this, can we take PhDs in this journal?

reply



Melanie Ortiz 8 months ago

SCImago Team

Dear Boumediene, thank you very much for your comment.

SCImago Journal and Country Rank uses Scopus data, our impact indicator is the SJR.

Check out our web to localize the journal. We suggest you to consult the Journal Citation Report for other indicators (like Impact Factor) with a Web of Science data source. For

further information about this journal, please visit the journal's website. Best Regards,
SCImago Team

P **PARU** 9 months ago

IOP CONFERENCE SERIES A BOOK OR JOURNAL.

reply



Melanie Ortiz 9 months ago

SCImago Team

Dear Paru,

Thank you for contacting us.

SJR is a portal with scientometric indicators of journals indexed in Scopus. All the data have been provided By Scopus /Elsevier and SCImago doesn't have the authority over this data which are property of Scopus/Elsevier. SCImago has a signed agreement that limits our performance to the generation of scientometric indicators derived from the metadata sent in the last update. Apparently, Scopus has categorized this publication in "Conference and Proceedings" section. We suggest you to contact with Scopus support regarding this request:

https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus/.

Best Regards, SCImago Team



Hebatalrahman Hebatalrahman 10 months ago

please what is value can express impact factor for IOP conference series material science and engineering

reply



Melanie Ortiz 9 months ago

SCImago Team

Dear Hebatalrahman, thank you very much for your comment.

SCImago Journal and Country Rank uses Scopus data, our impact indicator is the SJR.

Check out our web to localize the journal. We suggest you to consult the Journal Citation Report for other indicators (like Impact Factor) with a Web of Science data source. Best Regards, SCImago Team

A **Andrei** 10 months ago

No me carga el cuartil, saben porqué se debe eso?

reply



Melanie Ortiz 10 months ago

SCImago Team

Dear Andrei,

Thank you for contacting us. We calculate the SJR data for all the publication types, but the Quartile data are only calculated for Journal type's publications. Best regards,
SCImago Team

K **Kassim** 11 months ago

Hello

I want know that is Elsevier a publisher of this journal?

reply

M **MADHU LATA BHARTI** 1 year ago

please tell me if this journal is ugc listed, if it is, what is its ugc approval number?

reply

O **Ondrej** 1 year ago

Madhu means if the journal is approved and listed in University Grants Commission of India.

It is possible to find it out here (after registration):

<https://ugccare.unipune.ac.in/site/website/index.aspx>

However, IOP Conference Series: Materials Science and Engineering, is not, in fact, journal, but it collects proceedings from conferences, not journal articles. Still, the good thing is that IOP CS is WOS, Scopus (SJR) indexed. Generally, IOP publishing house is fair and reliable institution.



Melanie Ortiz 1 year ago

SCImago Team

Dear user, thanks for your participation! Best Regards, SCImago Team



Melanie Ortiz 1 year ago

Dear Madhu, could you please expand your comment? Best Regards, SCImago Team

O **osamah raad** 1 year ago

please how can I know the dates future conferences of IOP? are there any website for that purpose?

Regards

reply

K **Kabiru** 1 year ago

Dear Elena,

If IOP is a conference, then papers published in it are Scopus journal articles or just conference papers?

I was told that the papers published in IOP: material science and engineering are Scopus indexed journal papers with Scopus Q-ranking.

We need this for our Ph.D. graduation requirement.

THANK YOU

reply



Elena Corera 1 year ago

SCImago Team

Dear Kabiru, thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you consult the Scopus database directly. Remember that the SJR is a static image of a database (Scopus) which is changing every day. Best regards, SCImago Team

A **Asha Rajiv** 2 years ago

Wanted to know whether the journal is scopus indexed?

reply



Elena Corera 2 years ago

Dear Asha,

please, check comments below.

Best regards,
SCImago Team



a ridwan 2 years ago

if this conference and proceeding indexed by scopus how could i find my id author in scopus ?

reply

S Salam Jabr 1 year ago

<https://www.eetc-pec19.org/?>

[fbclid=IwAR2IOrbhvf6gtCwmddESpBVea7_p9MCW_bw3WUzzZV1IB5BMgl6d5FA1mA](https://www.facebook.com/eetc-pec19/?fbclid=IwAR2IOrbhvf6gtCwmddESpBVea7_p9MCW_bw3WUzzZV1IB5BMgl6d5FA1mA)



Elena Corera 2 years ago

Dear A Ridwan,

thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you contact Scopus

https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus/

Best Regards,
SCImago Team

T Thanikasalam 2 years ago

Hi, is this Scopus indexed?

reply



Elena Corera 2 years ago

Dear Thanikasalam,
thank you for your request, all the journals included in SJR are indexed in Scopus. Elsevier / Scopus is our data provider.
Best Regards,
SCImago Team



Dr. Ellahi 2 years ago

Dear Mam,
Just i want to ask you it is SCI, SCIE, OR EI or other journal? I know it is conference proceeding journal.
Thanks.

reply



Elena Corera 2 years ago

SCImago Team

Dear Dr Ellahi, SCImago Journal and Country Rank uses Scopus data, our impact indicator is the SJR. Check our page to locate the journal. We suggest you consult the Journal Citation Report for other indicators (like Impact Factor) with a Web of Science data source. Best Regards, SCImago Team

N

Nikhil jain 2 years ago

Madam icame 2018 conference papers not published yet can you tell me status

reply



Elena Corera 2 years ago

SCImago Team

Dear Nikhil,

articles publicated in 2018 are not over yet (we are in September). 2018 indicators will not be available until June 2019. We can not see what will happen in the future with this journal. SCImago receives the data from Scopus / Elsevier annually and does not have the authority to include, exclude or modify the data provided by Scopus.

Best Regards,
SCImago Team

M **Moisés Toapanta** 2 years ago

The IOP Conference is considered a research journal or only remains in conference proceedings. What is the difference of the SJR impact between a conference journal and a scientific journal

reply



Elena Corera 2 years ago

SCImago Team

Dear Moisés,
thank you very much for your comment. This journal is a conference proceedings. We only do an SJR calculation, it is the same for any type of publication
Best Regards,
SCImago Team

V **Vadym** 2 years ago

Dears, colleagues!

The journal IOP Conference Series: Materials Science and Engineering is it Q3 or Q4?

Best Regards

reply



ahmad fauzi 6 months ago

why journal of physics (IOP conferences has Q3? but the journal don't have. Both of them are conferences



Elena Corera 2 years ago

SCImago Team

Dear friend,
It's a conference, it does not have a quartile.
<https://www.scimagojr.com/journalsearch.php?q=19700200831&tip=sid&clean=0>
Best Regards, SRG

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Melt Rheological Behavior of High Density Polyethylene/Poly(Vinyl Alcohol) Fiber Composites Prepared via Melt Compounding Method

To cite this article: A. Chafidz *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **543** 012038

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Melt Rheological Behavior of High Density Polyethylene/Poly(Vinyl Alcohol) Fiber Composites Prepared via Melt Compounding Method

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²Chemical Engineering Department, Universitas Negeri Semarang, Semarang 50229, Indonesia

³Chemical Engineering Department, Universitas Muhammadiyah Purwokerto, Purwokerto 53182, Indonesia

⁴Chemical Engineering Department, Institut Teknologi Nasional, Bandung 40124, Indonesia

*E-mail: lucky.nuzulia@uii.ac.id

Abstract. In this work, high density polyethylene (HDPE)/poly(vinyl alcohol) (PVA) fiber composites have been fabricated via melt compounding by employing a twin-screw extruder. The resulted composites samples of four different PVA fiber loadings (i.e. 0, 5, 10, and 20 wt%) were then characterized using an oscillatory rheometer to investigate the effect of PVA loadings on their melt rheological behavior (e.g. storage modulus, loss modulus, complex viscosity). Additionally, the surface morphology of cryo-fractured surface of the composites were also investigated by using a scanning electron microscopy (SEM). The SEM micrographs showed that PVA fibers were perfectly embedded and well blended in HDPE matrix. Additionally, the melt rheological analysis results showed that the complex viscosity of all nanocomposites samples (i.e. PVAC-5, PVAC-10, and PVAC-20) were higher than that of neat PP (i.e. PVAC-0) and increased with the increase of nanoclay concentrations. Moreover, to further study the relationship between the PVA fiber loadings and complex viscosity of the composites, a well-known Carreau-Yasuda equation was employed to model the complex viscosity data from the rheological test. It was found that the equation fitted well the rheological test data.

1. Introduction

It is well-known that plastics have been widely used in the world and become part of our life. It was due to their many advantages (e.g. low density, low price, good mechanical properties, various applications, easily to process into any kind of forms) compared to other materials (e.g. metals, ceramics, wood, etc). High density polyethylene (HDPE) is considered as one of the most widely and frequently used thermoplastic polymers. It has been used in many applications, e.g. packaging, boxes, household goods, piping, etc. It is because HDPE is low cost, low density, good chemical and corrosion resistance, easy to be processed and recycled [1]. Moreover, its properties could be enhanced by blending and filling with reinforcing materials, i.e. micro-/nano-fillers, fibers, etc [2].

In other hand, poly(vinyl) alcohol (PVA) is a biodegradable type of thermoplastic polymers made from vinyl acetate. PVA fibers can be considered as one of fibers that have high reinforcement performance and have demonstrated good results in terms of tensile strain capacity, toughness, and crack bridging properties. Additionally, these fibers also suitable for many applications due to their high resistance to UV, chemicals/alkali, abrasion, and fatigue [3]. Recently, PVA fibers have been widely used in



construction applications, such as in fiber reinforced cementitious composites (FRCC) [4, 5]. The FRCC at least consists of three phases, which are: cement paste/matrix, fiber, and aggregates. The incorporation of fibers in FRCC may increase the energy absorption/toughness, strength, and/or strain of the FRCC [3]. Additionally, PVA fiber can also be used to fabricate polymer/PVA fiber based composites. There have been several literatures about polymer/PVA fiber based composites. Wu et al. [2] studied the preparation and characterization of HDPE/PVA. They found that the mechanical properties of HDPE increased with the addition of PVA fiber. Nevertheless, there have been limited number of literatures that studied PVA fiber filled polymer based composites, and thus it becomes an interesting topic of research.

One of the most preferred and widely used method to fabricate polymer composites is melt compounding. It is because this method is quite simple, low cost, and “green” method since no-solvent is used. Furthermore, this method is very suitable with the plastic industrial machines (i.e. extruder, injection molding), which makes the industrial scale production and commercialization of the polymer composites becomes easier [6, 7]. One of the key factors to fully understand the internal morphology/structure and processability (especially via extrusion/injection molding) of the composites is by studying their melt rheological properties. To the best of our knowledge, the number research studies regarding with the melt rheological studies of HDPE/PVA fiber composites are still limited, and thus it becomes an interesting topic of research. The present work focuses on the fabrication of HDPE/PVA fiber composites and characterization their morphology and melt rheological properties of the prepared nanocomposites.

2. Experimental

2.1. Materials

High density polyethylene (HDPE)/Polyvinyl alcohol (PVA) fiber composites were fabricated by melt compounding HDPE pellets (product name: M-300054, from SABIC, Saudi Arabia) with PVA fibers (product name: RECS15, from Kuraray, Japan). The HDPE has density of 954 kg/m^3 and melt flow index (MFI) of 30.0 g/10 min (low melt viscosity). Whereas, the PVA fiber has diameter 0.04 mm , thickness of 15 dtex , cut length of 8 mm , specific gravity of 1.3 . Figures 1a and 1b show the appearances of HDPE pellets and PVA fibers, respectively. Whereas, Figure 1c shows a scanning electron microscopy (SEM) image of single of PVA fiber.

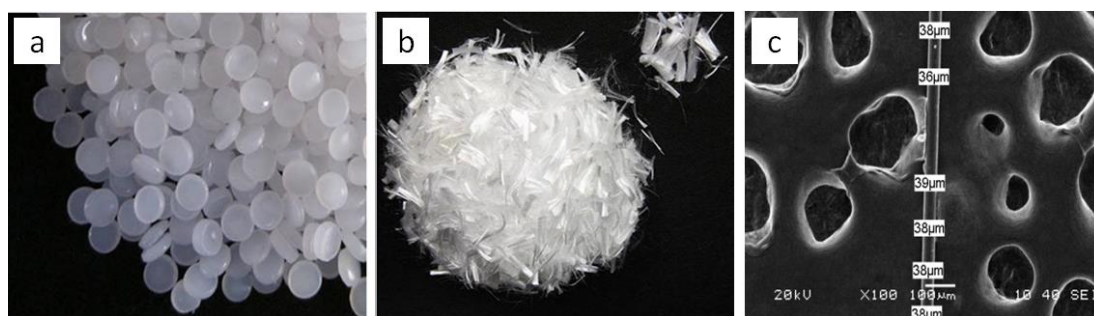


Figure 1. a) Photograph of HDPE pellets; b) photograph of PVA fibers; and c) SEM image of a single PVA fiber

2.2. Composites preparation

The melt compounding process was carried out in a twin-screw extruder (TSE) (Farrell FTX-20, UK) at screw speed of 17 rpm and die temperature of $200 \text{ }^\circ\text{C}$. The melt composites from the die was then cooled down in waterbath, dried (using air blower), pelletized (by cutting machine), and put in oven for moisture removal. After completely dried, the composites pellets were then molded into ASTM standard samples using an injection molding machine (Super Master, SM120, from Asian Plastic Machinery Co., China). The HDPE/PVA fiber composites were fabricated at four different PVA loadings, i.e. 0, 5, 10,

20 wt%, which correspond to PVAC-0, PVAC-5, PVAC-10, PVAC-20, respectively. Figures 2a and 2b exhibit the appearances of twin-screw extruder (TSE) and injection molding machine used in this work.

2.3. Composites characterization

The surface morphological study was done by using a Scanning Electron Microscopy (SEM), JEOL JSM-6360A, Japan. The samples used for the SEM analysis were cryo-fractured molded bars. Prior to the SEM examination, the cryo-fractured bar samples were coated with a fine layer of gold to minimize the overcharging/overheating of the samples, and also to improve the signal and resolution. The composites samples were examined by the SEM at 15 kV and magnification of 200X. Additionally, the effects of PVA fiber loadings on the melt rheological behavior of HDPE/PVA fiber composites were examined by the use of an oscillatory rheometer ARG2 (from TA Instrument, USA). The melt rheological test was performed under frequency sweep procedure using parallel plates fixture. The testing conditions were as follow: strain of 0.01 %; fixed temperature of 150 °C; angular frequency range of 0.05 - 500 rad/s. The samples used in the melt rheological test were disk-like composites samples obtained from the injection molding. Prior to the melt rheological test, the disk-like sample was put in between the parallel plates, and conditioned at fixed temperature of 150 °C until the whole composites sample was completely melted. Before starting the analysis, the excess of samples melt around the parallel plates was removed using a scraper. The data generated from the melt rheological test was complex viscosity $|\eta^*|$ vs angular frequency (ω). Figures 2c and 2d exhibit the appearances of Scanning Electron Microscopy (SEM) and oscillatory rheometer apparatus used in this work.

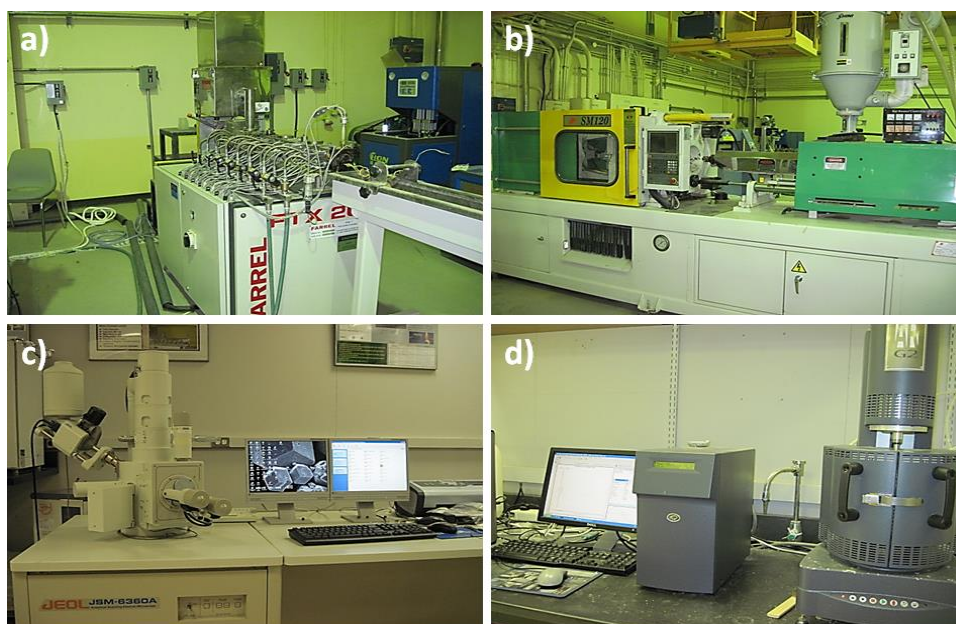


Figure 2. Photograph of a) Twin-screw extruder (TSE); b) Injection molding machine; c) Scanning Electron Microscopy (SEM); d) Oscillatory rheometer

3. Results and discussion

The surface morphology of the HDPE/PVA fiber composites has been examined by a Scanning Electron Microscopy (SEM). Figures 3a and 3b show the SEM images of HDPE/PVA composites, i.e. PVAC-0 and PVAC-10, respectively. The figure shows that the PVA fibers were well blended and embedded in the HDPE matrix (shown by the arrows). It was also observed that the fibers entangled one with the others. Additionally, it seemed that there were less interactions between the HDPE matrix and the PVA fibers (shown by the circle dashed-line). The SEM images of the other samples were similar but not presented in this paper.

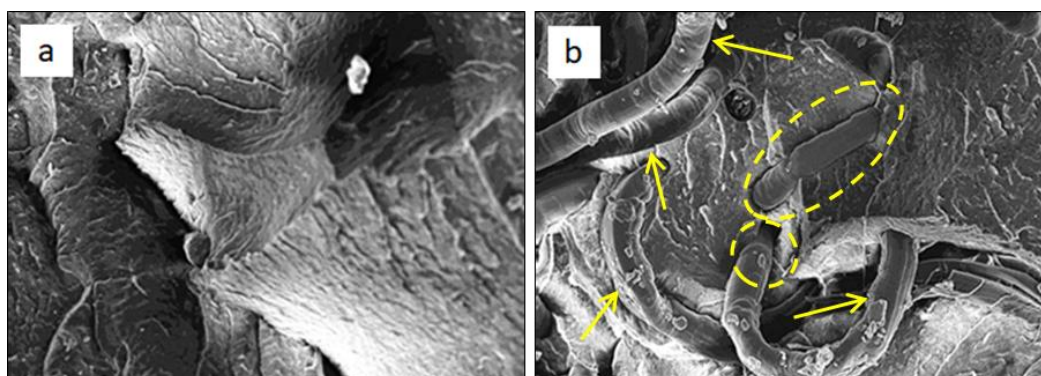


Figure 3. SEM images of cryo-fractured surface of HPDE/PVA fiber composites: a) PVAC-0 and b) PVAC-10

Additionally, the melt (state) rheological analysis of the HDPE/PVA fiber composites was carried out under torsion mode in parallel plate geometry using frequency sweep test. This test was performed at a constant temperature of 150 °C; constant strain of 0.1 %, and angular frequency range of 0.05 and 500 rad/s. Figure 4 shows the complex viscosity $|\eta^*|$ as function of angular frequency (ω) of HDPE/PVA fiber composites measured at fixed temperature of 150 °C. As seen in the figure, the complex viscosity of the composites were all higher than the neat HDPE. Furthermore, the improvement of complex viscosity was more significant at higher PVA loadings (i.e. PVAC-10 and PVAC-20) than at the lower one (PVAC-5).

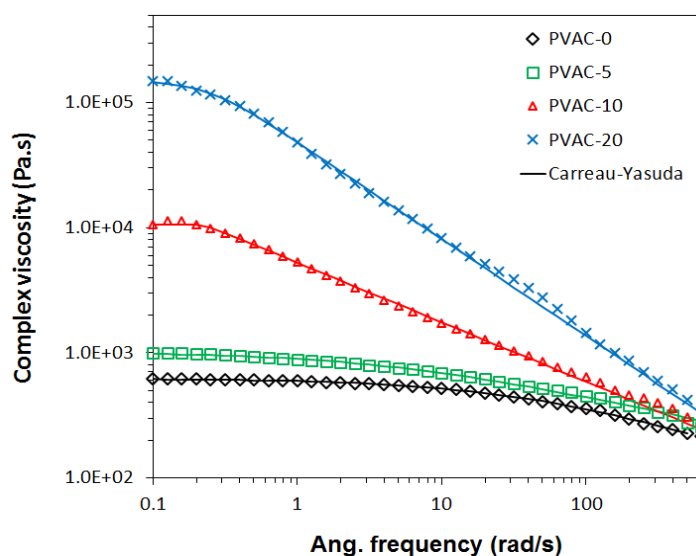


Figure 4. Complex viscosity $|\eta^*|$ as function of angular frequency (ω) for HDPE/PVA fiber composites at different PVA fiber loadings

Additionally, several complex viscosities of the composites samples (at several angular frequencies) are given in Table 1 and also plotted in Figure 5. Using these table and figure we could further observe the effect of PVA fiber loadings as well as the angular frequency on the complex viscosity of the HDPE/PVA fiber composites. As shown in Figure 5 and in accordance with Figure 4, the complex viscosity considerably increased with increasing PVA fiber loadings. The increase of complex viscosity $|\eta^*|$ was most likely due to the dispersion of the PVA fiber in the HDPE matrix, as well as the interaction between them, which resulted in the restricted mobility of HDPE molecular chains in the molten state.

Additionally, the rheological properties of composites materials could also be affected by the frictional interaction among the fillers as well as the interaction between the polymer chains and the fillers [8].

Table 1. Representative complex viscosity of HDPE/PVA fiber composites

Angular Frequency (rad/s)	Complex viscosity of HDPE/PVA fiber composites (Pa.s)			
	PVAC-0	PVAC-5	PVAC-10	PVAC-20
0.1	621.1	1004	10,630	1.49E+05
1	592.3	882.7	5,304	47,980
10	519.4	688.7	1,725	8,235
100	360.6	453.3	635.6	1,441
500	225.3	276.4	374.5	693.8

Furthermore, the increase of complex viscosity was prominent at lower angular frequencies (i.e. 0.1 – 10 rad/s). For example, at angular 100 rad/s the increases of complex viscosity of the composites were only about 0.26; 0.76; 3 times fold of the neat PP, for PVAC-5, 10, 20, respectively. Whereas, at angular frequency of 1 rad/s, the increases of complex viscosity were about 0.5; 8; 80 times fold of the neat PP, for PVAC-5, 10, 20, respectively. Furthermore, at angular frequency of 0.1 rad/s, the complex viscosity of the composites dramatically increased by 0.6; 16; and 240 times fold of the neat PP, for PVAC-5, 10, 20, respectively. At lower angular frequencies (i.e. 0.1 – 10 rad/s), the movement of HDPE molecular chains were very limited, due to the presence of PVA fiber and the interaction between both of them, and thus the complex viscosity was high. Whereas, when the angular frequency of the test increased, the HDPE molecular chains started to move (i.e. less restricted) regardless the presence of PVA fiber, and thus the complex viscosity started to decreased rapidly. This explanation was in accordance with the curve shape of PVAC-10 and PVAC-20 exhibited in Figure 4. The figure shows rapid decline of complex viscosity for both PVAC-10 and PVAC-20 as the angular frequency increased. This phenomenon was called “high shear-thinning” behavior. In the other hand, PVAC-0 and PVAC-5 showed “low shear-thinning” behavior, because the complex viscosity decrease gradually [8].

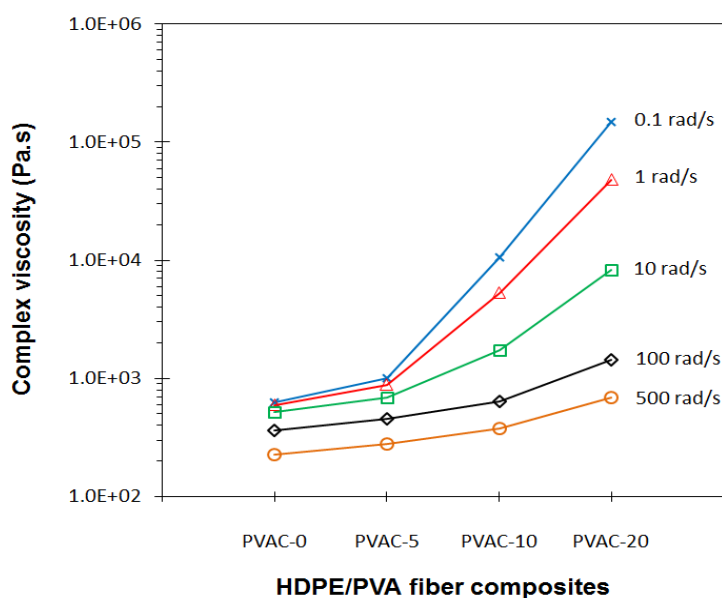


Figure 5. Representative complex viscosity $|\eta^*|$ of HDPE/PVA fiber composites at different angular frequencies

Additionally, to further study the complex viscosity $|\eta^*|$ behavior as function of angular frequency (ω) of the HDPE/PVA fiber composites, we have fitted the complex viscosity $|\eta^*|$ data from the frequency

sweep test results to the Carreau-Yasuda equation [9, 10], as shown in Eq (1). Figure 6 shows the schematic diagram of the Carreau-Yasuda equation.

$$\eta^*(\omega) = \eta_0 \left[1 + (\lambda\omega)^a \right]^{(n-1)/a} \quad (1)$$

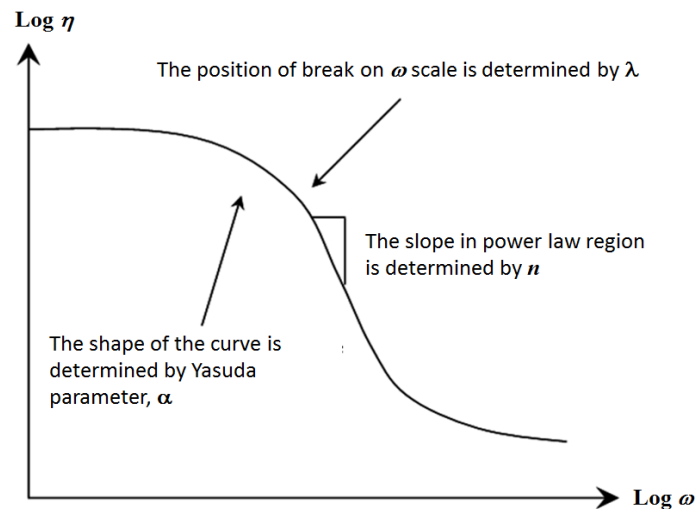


Figure 6. Schematic diagram of Carreau-Yasuda model

Where, η_0 is the zero shear viscosity (or complex viscosity, in this study), λ is the time constant (or cross-over time) and the inverse $1/\lambda$ is the critical value of shear rate (or angular frequency, in this study) at which the complex viscosity begins to decrease. The slope in the power-law region is given by $(n-1)$. Equation (1) reduces to the Newtonian fluid behavior for $n = 1$ and describes shear-thinning behavior when $n < 1$, while a is the Yasuda parameter which is attributed to the amplitude of the region of transition between η_0 and the power law region [9, 10]. All parameters, η_0 , λ , n , and a obtained from fitting complex viscosity data are listed in Table 2. As noticed from Figure 4, Carreau-Yasuda model fitted the complex viscosity data of the composites satisfactorily.

Table 2. Parameters with respect to the Carreau-Yasuda model for HDPE/PVA fiber composites

Sample	η_0	λ	n	A
PVAC-0	621.1	0.02	0.61	0.64
PVAC-5	1,004	0.24	0.75	0.68
PVAC-10	10,630	4.39	0.52	11
PVAC-20	1.49E+05	4.31	0.23	2.74

4. Conclusion

In the present work, HDPE/PVA fiber composites have been prepared via melt compounding method using a co-rotating twin screw extruder. The prepared composites samples were then characterized to study the effect of PVA fiber loadings on morphology and melt rheological properties of the composites. Morphological study revealed that all the composites samples showed that the PVA fibers were well blended and embedded in the HDPE matrix. Though it seemed that there were less interactions between the HDPE and PVA fibers. In the melt rheological analysis, the complex viscosity of all the composites samples increased with increasing PVA fiber contents at all angular frequencies. However, the improvement of $|\eta^*|$ was more prominent at lower angular frequencies (e.g. 0.1-10 rad/s) than at higher ones (e.g. 100, 500 rad/s). Additionally, composites samples PVAC-10 and PVAC-20 exhibited a “high shear-thinning” behavior as the angular frequency increased. In other hand, the PVAC-0 and PVAC-5 demonstrated a “low shear-thinning” behaviour.

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