PROCEEDINGS

2015 3rd International Conference on Adaptive and Intelligent Agroindustry (ICAIA)

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August 3rd - 4th, 2015
IPB International Convention Center
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Bogor Agricultural University

Bogor, Indonesia

Welcome Message from The General Chairs of ICAIA 2015

On behalf of the organizing committee, it is our pleasure to welcome you to International Conference on Adaptive and Intelligent Agroindustry, Bogor, Indonesia. This is the 3rd conference on the topic that is held by the Department of Agroindustrial Technology, Bogor Agricultural University, Indonesia.

The conference is expected to provide excellent opportunity to meet experts, to exchange information, and to strengthen the collaboration among researchers, engineers, and scholars from academia, government, and industry. In addition, the conference committee invited five renowned keynote speakers, i.e. Prof Irawadi from Bogor Agricultural University; Prof Kenneth De Jong from George Mason University, USA; Dr Yandra Arkeman from Bogor Agricultural University; and Dr Guillermo Baigorria from University of Nebraska-Lincoln, USA.

The conference committee also invited Prof Noel Lindsay from University of Adelaide, Australia; Kiyotada Hayashi from National Agricultural Research Center-Tsukuba, Japan; Prof Margareth Gfrerer from Islamic State University of Jakarta, Indonesia; Dr Barry Elsey from University of Adelaide, Australia; Dr Gajendran Kandasamy from Melbourne University, Autralia; and Imperial College London-British, Prof Allan O'Connor from University of Adelaide, Australia; Dr Wisnu Ananta Kusuma from Bogor Agricultural University ,Indonesia; and Dr Frank Neumann from University of Adelaide, Australia, as invited speakers.

This conference was organized by Department of Agroindustrial Technology, Bogor Agricultural University and Asosiasi Agroindustri Indonesia, and technically sponsored by IEEE Indonesia Section. Furthermore, it was supported by Departement of Computer Science, Bogor Agricultural University; Surfactant amd Bionegergy Research Center; PT Bogor Life Science and Technology; Indonesian Ministry of Industry; PT Pachira Distrinusa; and PT Kelola Mina Laut.

I would like to take this opportunity to express my deep appreciation to the conference’s committee members for their hard work and contribution throughout this conference. I would like to thank authors, reviewers, speakers, and session chairs for their support to participate in the Conference. Lastly, I would like to welcome you to join ICAIA 2015 and wish you all an enjoyable stay in Bogor.

Sincerely,
Dr Yandra Arkeman
General Chairs, ICAIA 2015

WELCOMING ADDRESS

Prof. Dr. Ir. Nastiti Siswi Indrasti
Head of Agroindustrial Technology Department
Faculty of Agricultural Engineering and Technology
Bogor Agricultural University

on

3rd International Conference on Adaptive and Intelligence Agroindustry (3rd ICAIA)

Bogor, August, 3 – 4, 2015

Assalamu'alaikum Warohmatullahi Wabarokatuh
In the name of Allah, the beneficent and the merciful,

Distinguish Guest, Ladies and Gentlemen
Let me first thank you all for accepting the invitation to participate in this 3rd International Conference on Adaptive and Intelligence Agroindustry (ICAIA). In particular I would like to thank Rector of IPB (Institut Pertanian Bogor/Bogor Agricultural University) Prof. Herry Suhardiyanto for supporting this event as part of the series academic event in celebrating the 52nd Anniversary of Bogor Agricultural University.

We are certainly proud to have been able to assemble this event in IPB, Bogor. The range of participants and audience at this conference is precisely something I would like to stress. Participants who followed the event more than 150 people, coming from various countries including the USA, Australia, Japan, Vietnam, Philippine, Germany and Indonesia. The main goal of the conference is to provide an effective forum for distinguished speakers, academicians, professional and practitioners coming from universities, research institutions, government agencies and industries to share or exchange their ideas, experience and recent progress in Adaptive and Intelligent Agroindustry.

The 2015 3rd International Conference on Adaptive and Intelligent Agro-industry (ICAIA) is the third forum for the presentation of new advances and research results on various topics in all aspects of innovative agro-industry that highlights the development and improvement for today and tomorrow's global need for food, energy, water and medicine. The aim of the conference is to stimulate interaction and cohesiveness among researchers in the vast areas of innovative agro-industry. Innovative Agro-industry has the ability to adapt intelligently to future global challenges, i.e. food, energy, water, and medical. Global challenges needs a new breed of Agroindustry which could produce innovative products to fulfill the needs through advanced processing technology, production systems and business strategy supported by cutting-edge information and communication technology.

The topic for this event is "Empowering Innovative Agroindustry for Natural Resources, Bioenergy and Food Sovereignty". The topics clustered into four main parts:
Track 1 : Innovative Agroindustrial and Business System Engineering

Track 2 : Frontier Approaches in Process and Bioprocess Engineering
Track 3 : Frontier Approaches in Industrial Environmental Engineering
Track 4 : Intelligent Information and Communication Technology for Adaptive Agroindustry of the Future

This event also hosts four (4) workshops: (1) Strategies for Agroindustry Development (2) LCA for Agroindustry (3) Innovation and Technopreneurship for Agroindustry and (4) Agroindustry Informatics.

Distinguish Guest, Ladies and Gentlement,
Agroindustry transforms agricultural commodities into high value-added products. Agroindustry is industry that process agricultural products to increase their value added significantly by using technology and by considering environmental aspect and sustainability. However, with changing global demand and technology advancement, innovative agroindustry is needed in order to be competitive as well as sustainable. The challenge of future agroindustry is not merely efficiency and productivity anymore, but also the challenge to appropriately apply frontier technology as well as meeting future global demands.

Agroindustry needs to deal with the application of advance technologies and cope future global issues. Current global issues which arise and expected to exist in the future are food sovereignty, renewable energy, sustainable water management and pharmacy. The ability of agro-industry to respond the future global issues and the undoubtedly substantial increase in demand in future decades will be highly dependent on the increased application of existing technologies as well as the exploitation of new and innovative technologies.

The emergence of high technology could be applied in the agro-industry are: nanotechnology, biotechnology, bioinformatics, food processing, food packaging-waste, state-of-the-art computation and many others. The aforementioned high-technology along with computation technology could greatly advance agro-industry from a traditional system into a smart-intelligent and innovative technology. Therefore, in the new millennia, adaptive-intelligent and innovative agro-industry will contribute to solutions to global problems and brings agriculture into perfection.

Hope this conference will also discuss this issue in more detail as it is an important matter for all of us. We should no more think just how to produce high value product but it is also necessarily important how to keep our live in good quality by understanding following old saying… “You do not live at once. You only die once and live every day”.

I do not to take up any more of your time with these opening remarks. Let me simply thank you once again for sharing your thoughts with us. Here’s wishing every success for the conference. May Allah bless all of us.

Thank you for your kind attention,
Wassalamu’alaikum Warohmatullahi Wabarokatuh

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AGENDA

Time	Activities
Monday, August 3rd 2015	
08.00 - 09.00	Registration
09.00 - 10.00	Opening Ceremony • Welcoming Address: Prof. Nastiti Siswi Indrasti (Head of DAT, Fateta, IPB) • Welcoming Speech Head of Bogor Regency • Conference Opening: Prof. Herry Suhardiyanto (Rector of IPB) • Opening Speech and Conference Opening : Minister of Industry Indonesia * • Launching Expose International program DAT
10.00 – 10.05	*Photo Session*
10.05 - 10.15	*Coffee break*
	Keynote Speech :
10.15 - 10.45	1. Prof Irawadi (Bogor Agricultural University, Indonesia)
10. 45 - 11.30	2. Prof. Kenneth De Jong (George Mason University, USA)
11.30 – 12.00	3. Dr. Yandra Arkeman (Bogor Agricultural University, Indonesia)
12.00 – 12.30	4. Dr. Guillermo Baigorria (University of Nebraska, Lincoln, USA)
12.30 – 13.30	Lunch break
	Plenary Session 1 :
13.30 – 13.50	Prof. Noel Lindsay (University of Adelaide, Australia)
13.50 – 14.10	Dr. Kiyotada Hayashi (National Agricultural Research Center, Tsukuba, Japan)
14.10 – 14.30	Prof. Margareth Gfrerer (Islamic State University of Jakarta, Indonesia)
14.30 – 14.50	Dr. Barry Elsey (University of Adelaide, Australia)
14.50 – 15.10	Ir. M. Novi Saputra (Marketing Director KML Food Group)
15.10 – 15.45	*Discussion*
15.30 – 15.45	*Coffee break*
15.45 – 18.00	Parallel session A, B and C
18.00 – 21.00	Welcome Dinner

Time	Activities
Tuesday, August 4rd 2015	
08.30 – 09.00	Registration
 09.00 – 09.20 09.20 – 09.40 09.40 – 10.00 10.00 – 10.20 10.20 – 10.45	Plenary Session 2 : Dr. Gajendran Kandasamy (PhD in Physic, Melbourne University ; PhD in Innovation Imperial Collage, London) Prof. Allan O'Connor (University of Adelaide, Australia) Dr. Eng. Wisnu Ananta Kusuma, ST, MT (Bogor Agricultural University, Indonesia) Dr. Frank Neumann (University of Adelaide, Australia) *Discussion*
10.45 – 13.00	Parallel Session A, B and C
13.00 – 14.00	Lunch break
14.00 – 15.30	Parallel Workshop • Strategies for Agroindustry Development • LCA for Agroindustry • Innovation and Technopreneurship for Agroindustry • Agroindustrial Informatics
15.30 – 15.45	Coffee Break
15.45 – 16.15	Closing remark

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New Trends in Industrial Environmental Engineering & Management

Intelligent Information & Communication Technology for Adaptive Agroindustry of the Future

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Synthesis and characterization of nanosilica from boiler ash with co-precipitation method

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Abstract*—Boiler ash known as solid waste of sugar industry with high silicon dioxide. Nanosilica can be synthesized from boiler ash with co-precipitation method. Precipitation still produced amorphous and heterogenous nanoparticles because of reaction spontanity. Modification using polysaccharides as dispersing agent improved its ability to synthesize homogenous silica nanoparticles. This study aimed to synthesize and characterize nanosilica from boiler ash with co-precipitation method. Polysaccharides that were used on this research include rice flour and agar powder with concentration 25% (w/w) silica. The characteristics of nanosilica were observed by particle size distribution, crystallinity, crystal size and morphology. Based on analysis, the use of polysaccharides as dispersing agent on precipitation method altered characterististics of nanosilica. Agar powder and rice flour reduced particle size and polydispersity index, turned crystallinity and crystal size, and formed unique particle morphology. The best characteristic of nanosilica was resulted by co-precipitation method using rice flour. It had average particle size 185.25 nm, polydispersity index 0.26, crystallinity 28.76%, average crystal size 22.44 nm.

I. INTRODUCTION

Boiler ash is a form of solid waste generated by the production activity of sugar industry. It is the result of chemical changes of pure bagasse burning at temperatures of 550-600°C for 4-8 hours. A large-scale sugar industry can produce 1.5-2.0% of the total sugarcane milled or about 1.7 to 2.3 million tons per year. Boiler ash has been utilized as the additional material for organic fertilizer, the fill of damaged roads and landslides [1]. Boiler ash is categorized as fly ash type F indicating that the boiler ash has a chemical composition of SiO_2, Al_2O_3 and Fe_2O_3 more than 70% and CaO less than 8%. It is this composition that makes boiler ash potential to be synthesized into silica. The synthesis of silica into nanosilica is carried out to expand the surface so that the reactivity increases.

The prevalent method of nanosilica synthesis is chemical precipitation, since it is excellent in the energy use efficiency and processing time. However, the use of precipitation method has not produced homogeneous nanosilica particles and a low degree of crystallinity [1]-[5]. An effort can be made to produce nanosilica particles with uniform size distribution is by the addition of a dispersing agent.In synthesis of nanosized oxide-based materials, polysaccharide played multiple roles, namely coating/capping, functionalizing, stabilizing, poring and or cordinating agent [6].Polysaccharide is a type of dispersing agent which is abundantly available and the residue management is relatively simple. The polysaccharides could be used in this study are rice and agar. Rice was one of agricultural comodities which could be used as non-metalic bio-precuesors to synthesize functional materials. Amylose and amylopectin of rice were representing the key structural elements for the synthesis of new functional nanomaterials [6]. Previously, rice used to synthesize zinc oxide nanoparticles [6]. Agarwas a natural, biocompatible and biodegradable carbohydrate derived from marine algae. Agar was composed of agarose and agaropectin. Agarose was preferred due to that it was porous, cheap, and environmental friendly. It has been used to prepare alumina nanoparticle [7] and the result was relatively good. The polysaccharide concentration used in the synthesis process will greatly affectedin its ability to control the particle sizes. Based on the research conducted by [8] for some types of polysaccharide-based dispersing agents, the polysaccharide concentration used was 25% (w/w).

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Wahyu K. Setiawan, STP, M.Si currently finish his study in Magister Program, Department of Agroindustrial Tecnology, Bogor Agricultural University (email: wks.f351124051@gmail.com).

Dr. Ir. Nastiti Siswi Indrasti is currently working as Professor and Head, Department of Agroindustrial Technology, Bogor Agricultural University(corresponding author to provide e-mail: nastiti.indrasti@ gmail.com).

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II. Materials and Methods

A. Materials

Boiler ash (BA) was obtained from PT Gunung Madu Plantation Lampung. BA from sugar factory cleaned by distilled water and burnt at 700°C for 7 hours. Sodium hydroxide (reagent grade), sulphuric acid and ammonium hydroxide (analytical grade) were purchased from Merck. Rice flour (RF) and agar powder (AP) was purchased from local market in Dramaga Bogor.

B. Synthesis of pure nanosilica from boiler ash

Ten grams BA on 80 ml 2.5 N sodium hydroxide solution was boiled in covered 250 ml erlenmeyer flask for 3 hours. The solution was filtered by whatman paper and the residues were washed with 20 ml boiling water. Then, the filtrate was allowed to cool down to room temperature and titrated 5 M H_2SO_4 until reached pH 2. Afterward, it was titrated again with NH_4OH until pH 7. Sol aged for 3.5 hours at room temperature then it was dried at 105°C for 12 hours [1][2][4].

C. Synthesis of nanosilica

Pure silica was refluxed on HCl 3 N for 6 hours. Thereafter, it was cleaned repeately with distilled water to free the acid. After that, it was dissolved on 2.5 N NOH by constant stirring on magnetic stirrer for 4 hours. Rice flour or agar powder 25% (w/w silica) was added into the solution after one hour. Then, 5M H_2SO_4 was titrated into solution to adjust pH 7.0-8.5. The precipitated silica was cleaned repeately with warm water to free the alkaly. At the end, it was dried in the oven 60°C 3 hours and burned at 700°C for 4 hours to calcinate the polysaccharides.

III. Characterization

Particle size distribution of nanosilica was observed by *Vasco Particle Size Analyzer*. Exactly 0.1 grams nanosilica powder was dispersed into distilled water. Then, iIt was stirred on magnetic stirrer for 10 minutes and sonicated for 1 minute. Nanosilica particles were scanned by PSA for 2-5 minutes.

The diffraction pattern, crystallinity, size and phase of crystal was observed by *Shimadzu XRD-7000 Maxima X* with Cu-Ka radiation, voltage 40 kV, impendance 30 mA, and λ=1.54Å. Diffractograms was scanned at 10-60° with scanning rate 2°/minute on room temperature. Crystallinity of nanosilica was calculated by XRD-7000 software while crystal size of nanosilica was calculated by Scherrer Formula.

IV. Result and Discussion

A. Transformation of boiler ash became nanosilica

Boiler ash (BA) in this study was burned at 700°C for 7 hours in order to eliminate trash materials and change the crystallinity. Fresh BA was composed of 82.76% silicon dioxide and other compounds. Silicon dioxide compound increased after burning process became 99.00%. The crystallinity also increased from 50.26% became 97.56%.

The silica was extracted by sodium hydroxide with hydrolisis process at 90-100°C for 3 hours to form natrium silicate. Natrium silicate and silicon dioxide was obtained via the following reactions:

$$SiO_2 + NaOH \rightarrow Na_2SiO_3 + H_2O$$
$$Na_2SiO_3 + H_2SO_4 \rightarrow SiO_2 + Na_2SO_4 + H_2O$$

Natrium silicate was precipitated by sulphuric acid to reach stability of silica sol. The sol of silica reach stability at pH 8.5 and aging time 3.5 hours at 60 °C.

Synthesis of nanosilica was done by extraction process with high concentration of hydrochloric acid. The particle size of silica would be reduced in this process. The smaller particle was precipitated again with same reaction. The second precipitation process resulted the sol with smaller droplet size.

B. Particle size distribution of nanosilica

The use of synthesis method affected homogeneity of nanosilica particle sizes. *Fig. 1(a-c)* shows a shift in the value of particle size distribution. The average size and polydispersity of nanosilica particles decreased, regardless of the methods start from precipitation, co-precipitation AP, until co-precipitation RF. The curve width lessened with the use of polysaccharide in the precipitation process which showed the decline in the size range and dispersity of particles in the dispersion media.

Nanosilica as the result of precipitation had a maximum size of 9774.96 nm and the minimum 28.19 nm. The range of nanosilica particle sizes shifted and became narrower when agar was used as a dispersing agent with the largest particle size of 4676.59 nm and the smallest 23.45 nm. The size distribution curve shifted, becoming narrower when rice was used as a dispersing agent with the largest particle size of 1288.58 nm and the smallest 29.52 nm.

The precipitation could synthesize nanosilica with an average particle size of 269.42 nm, with a polydispersity index of 0.9190. The high index value of polydispersity indicated that the nanosilica particles produced by precipitation technique had a deficient particle size distribution. Extraction with hydrochloric acid was able to reduce the size of nanosilica but had not been able to prevent the agglomeration of particles spontaneously[1].

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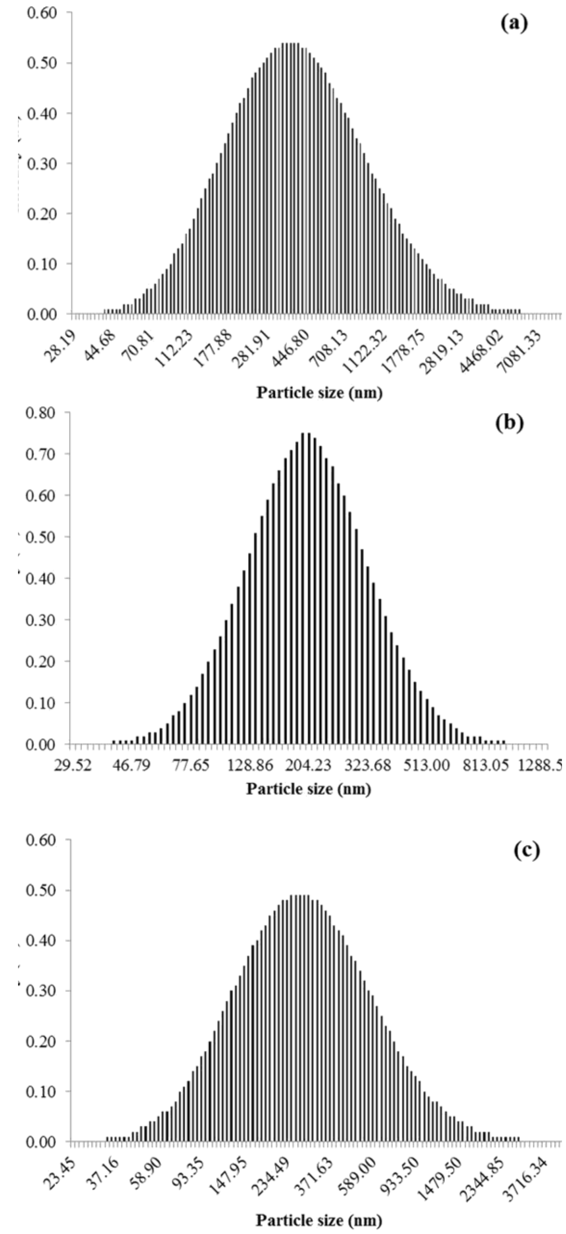

Fig. 1. Particles size distribution of nanosilica with different synthesis method (a) precipitation (b)co-precipitation RF (c)co-precipitation AP.

The use of polysaccharides in the precipitation process was able to synthesize nanosilica particle size distribution better than the synthesis result with ordinary precipitation. Rice flour as a dispersing agent in the precipitation process produced nanosilica particles with an average size of 185.45 nm, with a polydispersity index of 0.2540. Rice has starch granules consist of amylose molecules and amilopectin. In nanosilica synthesis, the carbon matrix have a helix shape in amylose and have a role in providing the morphological form and the uniformity of nanoparticle sizes.The hydroxyl groups ofamylopectin could be involved both in intra- and/orintermolecular supramolecular association. It had ability to coordinate transition metal ions, maintaining the nanoparticles highly aggregated [6]. RF on this research was obtained from high amylose rice, so that in nanosilica synthesis, amylose had more ability to control shape and size of particle.

As a result, the average size of synthesized nanosilica with co-precipitation AP was 252.22 nm, with a polydispersity index of 0.6520. The outcome of nanosilica formed still did not have a good size distribution. Resemble with rice, agar has granules which is consist of agarose and agaropectin. The high aggregation of nanosilica particle suspected due to the presence of high agarose relatively in the agar which was used as a dispersing agent. Agaropectin has the ability to associate into intra- or inter-molecules as a balancing agent Si^{2+} ion transition and maintaining a high aggregation between silica particles.

C. XRD analysis of nanosilica

The diffractograms in *Fig.2*illustrates the nanosilica diffraction pattern as a result of precipitation which had a value of 2θ with high intensity at 32.03°, 33.90°, 19.06°, and 28.07°. The highest intensity was at 32.03° which indicated the phase of cristobalite crystal [1]. Points 2θ 19.06° and 28.07° showed the presence of tridymite phase while the peak point (33.90°) indicated the presence of mullite phase. Domination of cristobalite phase showed that precipitated silica nanoparticles had good thermal stability. Cristobalite known as crystal phase of silica which was formed at 700-800 °C.

The precipitated silica nanoparticles with agar powder as the dispersing agent, had a diffraction pattern similar to precipitated nanosilica with higher intensity. The peak point with the highest intensity was found at 31.99°, 33.86°, 19.01°, and 28.04°. Based on *Fig. 2c*, there was not the peak point of agar. It indicates that agar was eliminated by calcination process at 700℃.

Meanwhile, nanosilica as a result of a synthesis with rice as the dispersing agent had the strongest peak at an angle of 2θ 22-23° which indicated an amorphous silica phase. Amorphous silica phase could be opal-A, opal CT or opal C. Crystalline phase was showed by the strong peak at 31.58° (cristobalite), 19.16° (trydimite) and 33.97° (mullite).

The degree of crystallinity indicated the proportion of the crystal phase which existed in the material. The nanosilica synthesis using the precipitation method produced particles with a crystallinity of 33.22% with a dominant silica cristobalite phase. The rice flour used as the dispersing agent was able to reduce the crystallinity of the particles up to 28.76%. Meanwhile, the agar flour was able to increase the crystallinity of the particles up to 59.53%. This crystallinity change was related to the composition of amylose in rice and agarose agar since both of the major compounds forming crystallinity.

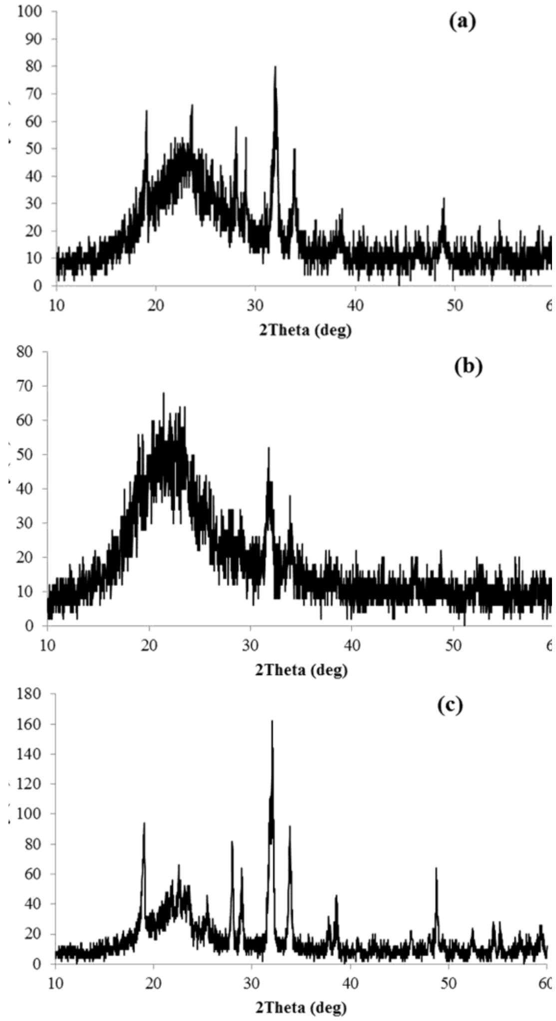

Fig. 2. Diffraction pattern of nanosilica with different synthesis method (a) precipitation (b)co-precipitation RF (c)co-precipitation AP.

In aqueous solution, rice granules swelled and their semi-crystalline structure was lost as smaller amylose molecule. The small amylose molecules could form a complex with Si^{2+} because of their high number of functional groups. Silicon ions and starch molecule would be asssociated then nucleation and initial crystal growth occured within regions of their high concentration. Van der Waals interaction between the surface molecules formed the driving force for self assembly. Then, SiO_2 nanocrystals can be assembled to reach larger size [6]. Similar to rice, agar granules also swelled in aqueous solution and formed larger agarose molecules. Agarose had same role with amylose, could be associated with silicon ions to form the nanocrystalline silicon dioxide.

Despite its fairly low degree of crystallinity, the crystal formed from the synthesis process had a relatively small size (Table1). The crystal size was obtained by calculating the average size of the crystals with high intensity. It was given by Scherrer formula [7].

$$D = \frac{k\lambda}{\beta\cos\theta}$$

where D crystallite size (nm), k Scherrer constant (0.9), λ wavelenght of Cu (0.154 nm), β full width at half maximum (FWHM), θ diffraction angle (deg).

The highest crystal size was obtained from nanosilica precipitation with an average crystal size of 27.17 nm, followed by agar nanosilica co-precipitation 26.80 nm and rice co-precipitation 22.44 nm. The third sample of nanosilica crystal size was smaller than the size of silica 91.53 nm. In general, the three methods of nanosilica synthesis were able to reduce the silica crystal size up to 70-75%. Acid hydrolisis on this process broke structure of silica crystal.

TABLE I
THE CRYSTAL SIZE OF NANOSILICA WITH DIFFERENT SYNTHESIS METHOD

Nanosilica									Crystal phase
Precipitation			Co-precipitation RF			Co-precipitation AP			
2θ (deg)	D(nm)	β (rad)	2θ (deg)	D(nm)	β (rad)	2θ (deg)	D(nm)	β (rad)	
19.06	26.28	0.0053	19.16	10.81	0.0126	19.01	27.05	0.0050	trydimite
22.65	25.05	0.0056	20.06	7.49	0.0181	22.60	18.63	0.0073	quartz
28.07	30.00	0.0047	28.01	30.42	0.0045	28.04	36.45	0.0038	seifertite
29.02	28.99	0.0049	29.16	66.07	0.0021	28.98	38.85	0.0036	cristobalite
32.03	**18.87**	**0.0079**	**31,85**	**12.28**	**0.0113**	**31.99**	**17.46**	**0.0080**	**cristobalite**
33.90	28.33	0.0051	33.97	21.11	0.0066	33.86	29.06	0.0048	cristobalite

Despite of crystal properties, XRD analysis could be used to analyze chemical composition of silica nanoparticles. It would be very important to assure purity of silica. Qualitative analysis of XRD on silica nanoparticles showed that SiO_2had high percentage 90-99% while another metal oxide had 1-10% in percentage. Functional group of silica by infra red spectra not to be expressed because the main characteristics of silica nanoparticle more enough. Silica nanoparticle which produced by co-precipitation RF had better properties if it to be applied for electrolyte membrane additive. Based on FTIR analysis [9], the band at 1072 cm^{-1} illustrated the presence of Si-O-Si, the band at 902 cm^{-1} for Si-O-H. Amorphous silica is known to have the ability as a semiconductor material due to its mechanical resistance, electricity, and good selectivity of chemical modification.

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The author would like to thank DGHE, Ministry of Research, Technology and Higher Education for research grant supporting this study. For instrument, gratitute to be expressed to Head of Material Analysis Laboratory, Physic Department, Bogor Agricultural University; and Material Analysis Laboratory, Center of Forest Research and Development, Forestry Department, Gunung Batu Bogor.

VI. Conclusion

Nanosilica can be synthesized from the boiler ash of sugar industry using both precipitation method and co-precipitation method. Modification of the precipitation process with agar powder and rice flour as a dispersing agent proved able to reduce the particle sizes, increase the particle size distribution, lower the crystal size, and change the crystallinity of nanosilica. The rice flour used in the precipitation produced nanosilica with the best characteristic, that is, with a particle size of 185.45 nm, polydispersity index of 0.2540, crystal size of 22.44 nm.

References

[1] A. Ismayana, "Design of Co-composting process and nanotechnology for handling of solid waste of sugar industry," Ph.D. dissertation, Dept. Agroindustrial Tech., Bogor Agr. Univ., Indonesia, 2014.

[2] N. Thuadaij and A. Nuntiya, "Preparation of nanosilica powder from rice husk ash by precipitation method," Chiang Mai J. Sci., vol. 35, no. 1, pp. 206-211, 2008.

[3] S. Music, N. Filipovic-Vincenkovic, and L. Sekovanic, "Precipitation of amorphous SiO2 particles and their properties," Brazilian Journal of Chemical Engineering, vol. 28, no. 1, pp. 89-94, 2011.

[4] V. Hariharan and G. Sivakumar, "Studies on synthesized nanosilica obtained from bagasse ash," International Journal of ChemTech Research, vol. 5, no. 3, pp. 1263-1266, 2013.

[5] V.H. Le, C. N. H. Thuc, and H. Thuc, "Synthesis of silica nanoparticles from Vietnamese rice husk by sol–gel method," Nanoscale Research Letters, vol. 8, no. 58, pp.1-10, 2013.

[6] D. Ramimogadham, M. Z. B. Hussein, Y. H. Taufiq-Yap, "Hydrothermal synthesis of zinc oxide nanoparticles using rice as soft biotemplate," Chemistry Central Journal, vol. 7, no. 136, pp. 1-10, 2013.

[7] M. A. Nawawi, M. S. Mastuli, N. H. A. Halim, and N. A. Z. Abidin, "Synthesis of alumina nanoparticles using agarose template," IJEIT, vol. 3, issue 1, pp. 337-340, July 2013.

[8] M. Nidhin, R. Indumathy, K. J. Sheeram, and B. U. Nair, "Synthesis of iron oxide nanoparticles of narrow size distribution on polysaccharide template," Bull mater Sci., vol. 31, no. 1, pp. 93-96, 2008.

[9] W. K. Setiawan, "Preparation of nanosilica from boiler ash with co-precipitation method as additive for electrolyte membrane based chitosan," M.Si. thesis, Dept. Agroindustrial Tech., Bogor Agr. Univ., Indonesia, 2015.