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Studies of Carbonization Process on the Production of Durian Peel Biobriquettes with Mixed Biomass Coconut and Palm Shells

To cite this article: Ellyta Sari *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **316** 012021

STUDIES OF CARBONIZATION PROCESS ON THE PRODUCTION OF DURIAN PEEL BIOBRIQUETTES WITH MIXED BIOMASS COCONUT AND PALM SHELLS

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Abstract. Biobriquettes as alternative energy that can replace the role of kerosene. Biobriquettes made from agricultural waste biomass. Biobriquettes durian peel has been researched and developed continuously to obtain optimal quality in terms of calorific value, compressive strength and duration of ignition. In making durian peel biobriquettes needed other biomass mix to sustain duration of Ignition for biobriquettes durian skin quickly burned out. Stages of making biobriquettes durian skin are: material of drying, carbonization of biomass, grinding, mixing with adhesives, and printing. Carbonization process is a process that is important in obtaining the biomass charcoal. Carbonization is done by means of karbonisator pyrolysis. The purpose of this research is to study the process of carbonization to obtain biobriquettes durian skin that of quality in terms of value compressive strength, calorific value, and duration of ignition. Variations that done was kind mix of biomass,coconut shells and palm shells with the massa ratio 2 : 1, type of adhesive used tapioca powder and banana peels, carbonization of temperature 200^{o}C, 300^{o}C and 400 ^{o}C . The results showed that the highest compressive strength of the durian skin with a mixture of coconut shell and adhesive tapioca powder and carbonization temperature of 300 ^{o}C namely 12,7 g/cm^2. The calorific value of the highest on the mix of skin durian with coconut shells and adhesive banana skin with temperature of carbonization 400 ^{o}C ie 6040 cal/g, and duration of ignition highest on a mixture of skin durian with coconut shell and adhesive banana skin at a temperature of carbonization 300 ^{o}C is 73 minutes.

Keywords **:** Biobriquettes, Durian peel , Carbonization.

1. Introduction

Renewable alternative energy sources is being developed in Indonesia. One of these is biobriquettes from biomass. Biomass is composed of cellulose, hemicellulose and lignin that is commonly found in plant parts. Biomass is a renewable reseources that can be used sustainably.

Durian peel waste is one of biomass that could be used as a raw material source of renewable energy. Several studies of Biobriquettes of durian peel has been conducted. (Pramudya, et al.,2011) studied the variation of biomass and adhesive mixture. However, these studies without using the carbonization process of durian peel. In the biobriquettes manufacture, carbonization is a very important process because it is the main process in the biobriquettes manufacture which can affect the biobriquettes quality.

Carbonization process is done by burning biomass in open condition, the burning process then stopped when the charcoal formed, by spraying water on the charcoal that has been formed. This kind of process generated a lot of ash and smoke so that the charcoal making process is not optimal and produced only a little charcoal. Therefore it is necessary to look for solutions, so that the carbonization process authoring maximum results, which produces little ash, it also can take advantage of combustion smoke as liquid smoke which can be used as a natural food preservative,which is not harmful.

This is known as pyrolysis process (Mira, M, 2002). The characteristics of durian peel as an alternative fuel by the pyrolysis process has been investigated (Wahidin, 2014). In this study, the ash content obtained is still high (18.8%), caused not using a mixture of biomass. The process of making biobriquettes by pyrolysis carbonization been done by (Feri Fuji,2010), at a temperatures of 210, 250, 300, 350, and 390^{0}C using rice husk as raw materials, and the highest calorific value obtained at 5609.453 cal/g. In addition (Warapon R, *et.al,* 2011) also examined biobriquettes durian peel with a mixture of rice straw (9: 1) the calorific value obtain is 24,674MJ/kg (5902 cal/g). While (G. Siresh, *et al,*2016) examined the types of palm briquette powder and binder, providing a calorific value of 20 945 MJ /kg (5010 cal/g) at 80.79% efficiency.

(Paisal,2014) conducted a study ofbiobriquettes made from durian peel using an adhesive with banana peel waste without mixing other biomass, and the calorific values obtained 5074 cal/g. (Sari, E, *et.al* ,2015) also did research on biobriquettes durian peel with a mixture of biomass palm shells and rubber shell, using starch as an adhesive.From this study, the highest calorific value obtained of 5118 cal/g. (Merry, *et.al,*2015) also examined using an adhesive calcium hydroxide and obtained calorific value of 4968 cal/g. Accordingly it is need to do research with the pyrolysis carbonization process of durian peel, so that the higher ash levels can be reduced by using a mixture of other biomass.

Moreover carbonization pyrolysis also produces liquid smoke which can be used as a preservative. This research will be carried out at a pyrolysis carbonization temperature of 200-400^{o}C with adhesive from banana peels waste and starch as a comparison, by add biomass from coconut shell and palm shell to increase the calorific value of biobriquettes.

The purpose of this study was to determine the effect of carbonization temperature to the biobriquettes result, the effect of biomass mixture with biomass durian peel to the calorific value, and the effect of adhesive type to quality of biobriquettes produced.

2. Methodology/ Experimental

This research was conducted at the Laboratory of Chemical Engineering, Universitas Bung Hatta Padang. The research parameters consist of Fixed Parameters, Variable Parameters, and Output Parameters. Fixed Parameters arebiomass of durian peel, adhesive: 10% from the total biomass mixture, biomass mixture with composition ratio 2: 1, with a total weight of biomass at 140 grams. Variable parameters is another biomass mixture,: palm shells, coconut shells; different types of adhesives: starch and banana peels; Carbonization temperature at 200, 300, and 400^{o}C. Output parameters are compression strength, porosity, calorific value, ash content and burning time.

2.1. Tools

Pyrolysis carbonization reactor, condenser, biomass cutlery, sifter, Mixers, grinding, Biobriquettes Molds, basin, Zinc for drying, Stove, Pots, Spatula, scales, oven, desiccator and porcelain dish.

2.2. Materials

Durian peels from Padang, Biomass mixture consist of palm shells, Coconut shell, adhesive from starch flour, banana peel, and water.

2.3. Working Procedures

2.3.1. Carbonization Stage by means of Pyrolysis Carbonization

a. The durian peel was chopped up small, so that the drying process can be faster and more volume of material can be fed into the reactor
b. All material is dried under the sun for 4-5 days.
c. once the ingredients dry, biomass was entered in the carbonization reactor, then temperatur of heating was set and biomass was entered until almost full and then reactor was covered tightly.
d. The heater is switched on and the carbonization temperature is adjusted (according to variations at 200, 300 and 400^{o}C) with a heating time of 2 hours each.
e. After two hours, pull out the carbonization results, then crush until smooth at size of 60 mesh.
f. The same thing is done on another biomass mixture; palm shell and coconut shell

2.3.2. Adhesives Manufacturing Phase

A. MakingAdhesives From Starch

Starch weighed as much as 10% of the total biomass feedstock, next insert the water at a ratio of 1: 10, then stirred. Starch solution was then heated on a stove until thickened.

B. Making Adhesives from Banana Peel

Banana peel retted ± 10 days, then was mashed. The smooth banana peel is mixed with 10% of the total weight of the biomass feedstock, then was add water gradually until homogeneous.

2.3.3. Briquetting Phase

The smooth durian peels charcoal is weighed according to the specified weight and the specified biomass variation. The refined durian peel is mixed with the adhesive in the container while stirring until evenly Further the mixture were molded using biobriquettes mold. Biobriquettes then dried under the sun until completely dry.

2.4. The tools image series can be seen in Figure 1.

Figure 1. The series of pyrolysis carbonisator dual function tool

Information :
1. Reactor; 2. Furnace; 3.Thermometer; 4. Pressure Gauge; 5. Condenser; 6. The Hot Water flow; 7. The Cold Water flow in; 8. Condensate Flow; 9. Liquid smoke Container; 10. The cooling water hose

IOP Conf. Series: Materials Science and Engineering **316** (2018) 012021 doi:10.1088/1757-899X/316/1/012021

3. Results and Dicussion

Biobriquettes shape produced from the research of Manufacturing of biobriquettesdurian peel from the mixture of biomass and adhesive, can be seen in Figure 2.

Figure 2. Biobriquettes of Mixture of Biomass and Adhesives

3.1. Effect of Raw Materials to the Biobriquettes Porosity/ Density

Porosity/density is the ratio between the weight to the volume of briquettes. Density size is influenced by the size and homogeneity of the briquettes materials. Based on observations and calculations performed on the density value of each treatment,smaller particle size can expand the field of bonding between powders, thus increasing the density of briquettes (Masturin 2002). The effect of a biomass mixture to porosity can be seen in Figure 3 and Figure 4.

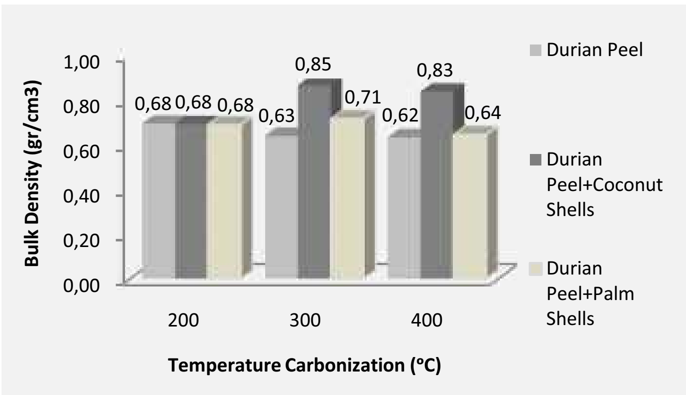

Figure 3. Effect of Biomass Mixture Using Adhesives Starch To The Porosity

From Figure 3 and Figure 4 can be seen that the mixing of biomass coconut shell and palm shells charcoal with durian peel (agricultural waste) at a smaller size (60 mesh) could expand the bonding between particles, thereby increasing the biobriquettesdensity, since the bonds between powder are stronger and more compact.

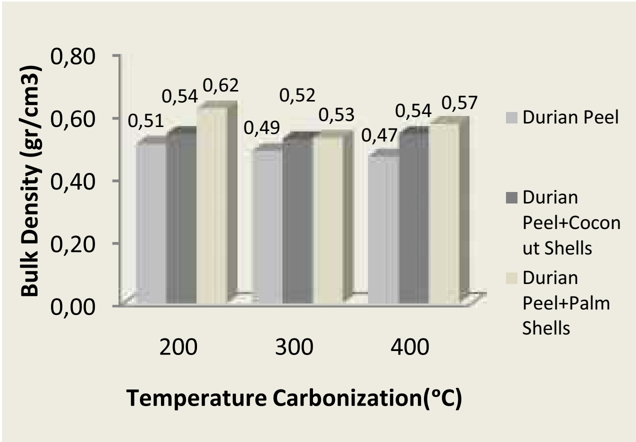

Figure 4. Effect of Biomass Mixture Using Adhesives Banana Peel to the Porosity

Figure 3 and Figure 4 show that biobriquettes porosity values ranged from 0.47 to 0.85 g/cm^3. Biobriquettes with adhesive starch obtained the best porosity of 0.85 g /cm^3 with a mix of biomass durian peel and coconut shell, while biobriquettes with adhesive banana peel earned best porosity of 0.62 g/cm^3 with a mixture of durian peel biomass and palm shells. Adhesive banana peel does not have a strong bond between the fibers, it is because the banana peel adhesion is not as strong of starch adhesion. This leads to a lower density value. Thus, the composition of the constituent material effect the biobriquettes density.

3.2 Effect of the Mixture of Biomass and Adhesive on CompressionStrength

Effect of biomass mixture and adhesive onbiobriquettescompression strength can be seen in Figure 5 and Figure 6.

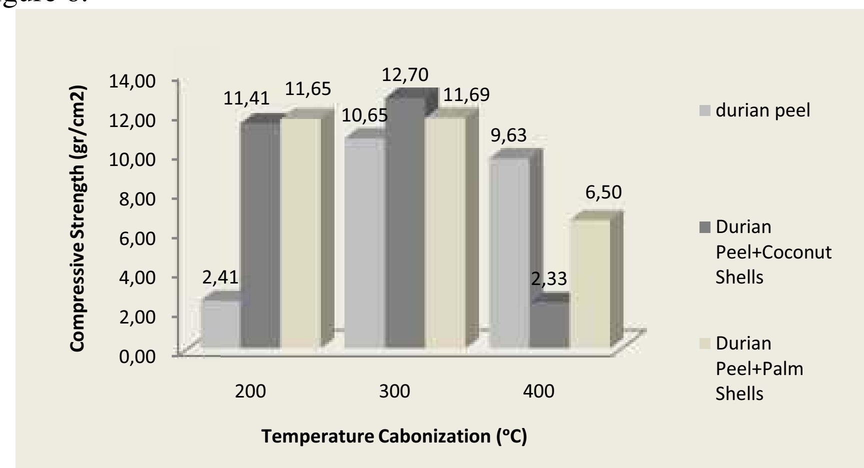

Figure 5. Effect of Biomass Mixture using Adhesives Starch To The Compression Strength

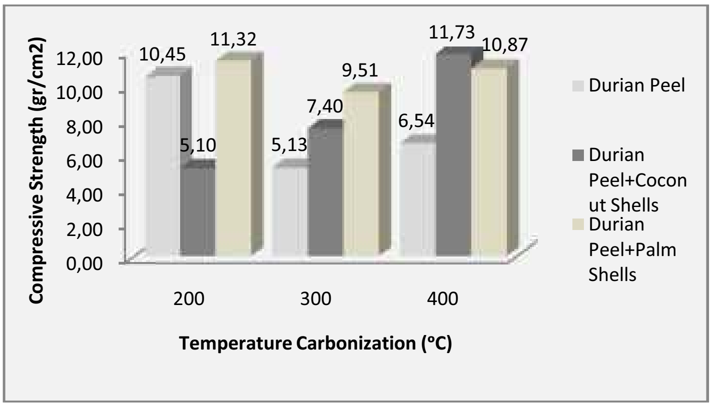

Figure 6. Effect of Biomass Mixture Using Adhesives Banana Peels To The Compression Strength

Figure 6 and 7 shows that the highest compression strength at 12.70 g/cm^2, using adhesive starch with a mixture of coconut shell biomass at temperatures of 300^{o}C, while the highest compression strength using adhesive banana peel with a mixture of biomass palm shell at temperature of 400^{o}C, namely 11.73 g/cm^2.

Adhesive starch has a better compression strength than adhesive banana peel, this is due to starch adhesion is higher than banana peel, moreover high density biomass would produce high compression strength biobriquettes as well, as proposed by (Sudrajat,1984), that charcoal biobriquettes from high density raw materials will also provide a high compression strength

3.3. The Effect of Biomas Mixture and Adhesive to the Calorific Value

The biomass mixture and adhesives used in biobriquettes manufacture also affect the calorific value. Each sample variation had been tested the calorific value.

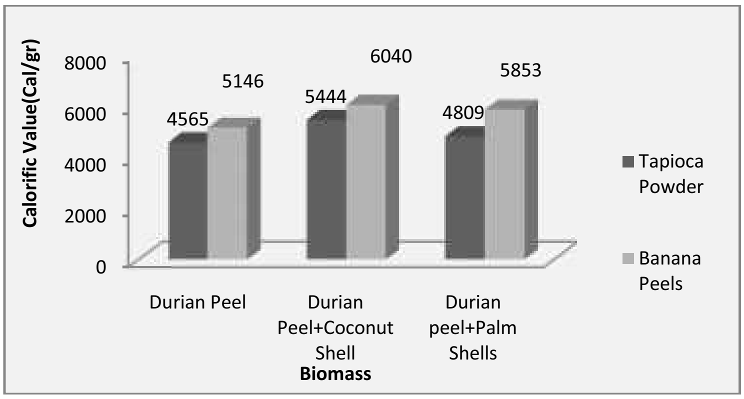

Figure 7. The Effectof Biomass Mixture and Adhesives To The Calorific Value

Figure 7 show that the increasing of calorific value is also influenced by a mixture of biomass used. Calorific value of Biobriquettes durian peel without other biomass mixture are 4564 and

5146 cal/g, and the calorific value were increased become 5444 and 6040 cal/g when biobriquettes durian peel mixed with coconut shell,.
Calorific value of biomass using a mixture of palm shells decreased to 4809 and 5853 cal/g. In the research by Pramudya, et.al (2011), the highest calorific value obtainedon durian peels and palm shells with jackfruit seed adhesive was 5495 cal / gr. Thereby it can be concluded that the used of adhesive type is can influenced the caloric value. Banana peel adhesive gives the higest calorific values than with the jackfruit seeds adhesive in research Pramudya ,et.al (2011).

The addition of biomass can increase the calorific value of biobriquettes durian peel. The addition of coconut shell biomass provides the best calorific value. This is due to coconut shell has a high carbon compound that gives additional calorific value to the durian peel biobriquettes produced. Adhesive type is also affects the calorific value obtained. Figure 7 shows that adhesive banana peel provides a higher calorific value than adhesive starch.

3.4. Effect of carbonization temperature and biomass mixture to the Burning Time

Effect of carbonisation temperature and biomass mixtures to the biobriquettes burning time can be seen in Figure 8 and Figure 9.

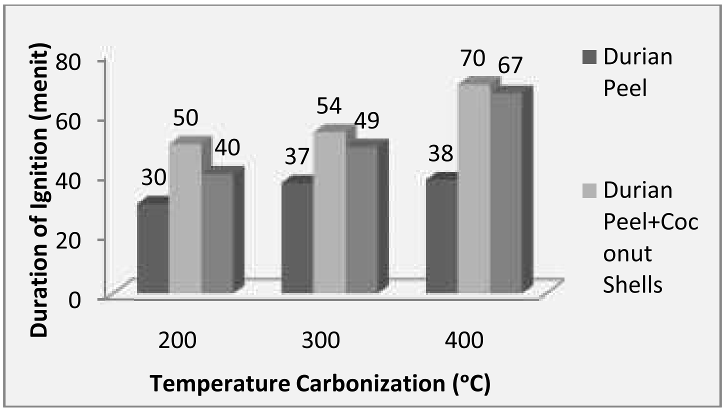

Figure 8. Effect of Carbonisation Temperature and Biomass Mixture Using Adhesives Starch To The Burning Time

Figure 8 and Figure 9 shows that the best burning time of biobriquettes obtained at carbonization temperature of 400°C ie 73 minutes on biobriquettes with adhesive banana peel and coconut shell mixture.This is because the burning temperature of 400 °C completely carbonized biomass as compared with 200°C and 300°C burning temperature, so that the carbon content tied will be higher at burning temperature of 400 °C, so the biobriquettes ignition time to ashes will be longer.

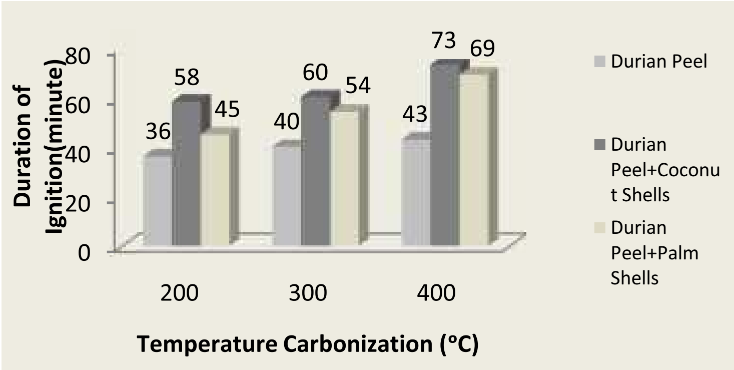

Figure 9. Effect of Carbonisation Temperature and Biomass Mixture Using Adhesive banana peels To The Burning Time

The effect of biomass mixture show that Biobriquettes mix with coconut shells provide the best ignition when compared with other. In research by Munas, et.all (2012) that the best burning time of biobriquettes is 40 minutes on biobriquettes with cocoa beans biomass without the addition of other biomass, but in this study the best burning time of biobriquettes is 73 minutes on biobriquettes with durian peels and coconut shells with banana peel s adhesive.

3.5. Effect of Carbonization Temperature and Biomass Mixture to Ash Content

Effect of carbonization temperature and the biomass mixture to ash content can be seen in Figure 10 and 11.

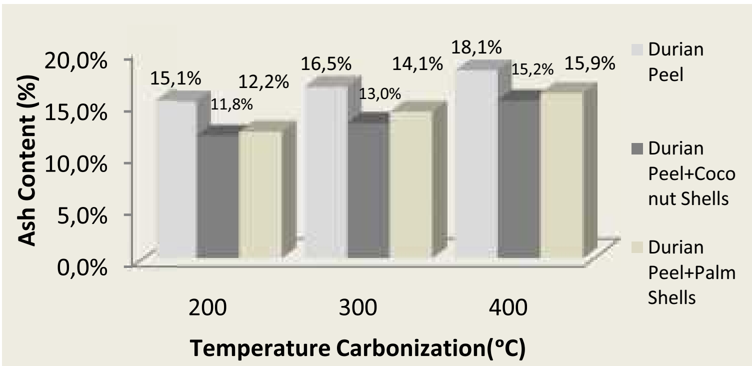

Figure 10. Effect of Carbonisation Temperature and Biomass Mixture using Adhesive starchs To Ash Content

Figure 10 and 11 shows that ash content obtained ranged between 10% - 24%. Ash content obtained is not yet meet the standards of <10%. Carbonization temperature of 400 ^{o}C give the highest ash content compared to the carbonization temperature of 200 ^{o}C and 300 ^{o}C.

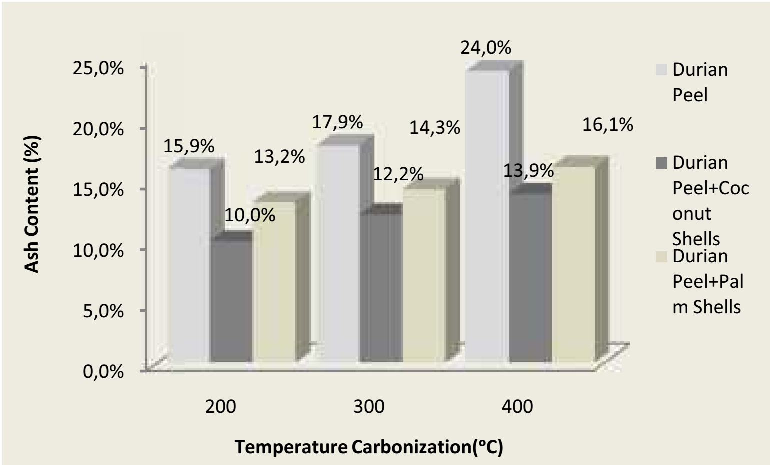

Figure 11. Effect of Carbonisation temperature and Biomass Mixture Using Adhesive banana peels To Ash Content

This is due to the ash content will increase at the higher carbonization temperature. Carbon will burn out at higher temperature and leave the ashes as a result from the combustion (Rosdiana, 2016), so it can be said that the carbonization temperature rise is directly proportional to the biobriquettesash content. On the influence of the biomass mixture, biobriquette mixture of durian peel with coconut shell biomass with adhesive banana peel provide the best ash content is 10%. In research by Pramudya, et. All (2011), biobriquettes mixture of durian peel with palm shell biomass with durian seeds adhesive provides the lowest ash content is 11.90%. This is due to mineral deposits that can not be burned in the coconut shell is lower compared to the others, so that the ash obtained is also low.

4. Conclusion

Results from the study of biobriquettes durian peel give some following conclusions:

a. Utilisation of durian peel waste, coconut shell, and palm shells on making biobriquettes may increase the economic value of raw materials.,
b. Banana peel waste can be use as an adhesive in the biobriquettes manufacture, but the adhesiveness given still low compared than adhesive starch, but adhesive banana peel can improve the calorific value of biobriquettes.
c. The addition of coconut shell and palm shell biomass improve the quality of biobriquettes durian peel.
d. Biobriquettes has the highest calorific value at 400^{o}C carbonization temperature, with a mixture of coconut shell and adhesive banana peel of 6040 cal/g. Calorific values obtained reached the calorific standard based on ISO (5000 cal/g).

5. Acknowledgement

Thanks to all the parties concerned to this study: the Higher Education Research and

Technology which funded this research through grants applied, also to all students of guidance that help a lot of this research.

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In 2007 he left UCL to become the Chief Executive Officer of the Engineering and Physical Sciences Research Council, stepping down in 2014. He was then Chair of the Defence Scientific Advisory Council from 2014 to 2017 and Chair of the Strategic Advisory Board for the UK National Quantum Technologies Programme from 2014 to 2019.

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She is currently President of the Publishers Association.

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Prior to moving to the BMA, Tom led the Royal College of Anaesthetists, which grew substantially under his leadership, and before this was Executive Director of Strategy, Communications and Policy at the Royal College of Physicians, England's oldest medical royal college, where he was also interim Chief Executive and introduced the organisation's first ever strategy in its 500-year history.

Miriam Maus, Chief Publishing Officer, IOP Publishing

As Chief Publishing Officer at IOP Publishing (IOPP), Miriam is responsible for the creation and delivery of the organisation's publishing and researcher engagement strategy.
Working with a global team of publishing and marketing professionals, Miriam ensures that IOPP's publishing activities deliver trusted content of high quality and that the organisation takes a leadership role in publishing ethics and integrity, inclusive and transparent publishing practices and that the power of technology is harnessed to improve the publishing experience for all involved.
During her 25 years in academic publishing Miriam has created strategies, developed business opportunities and led diverse teams through periods of change and growth. Prior to joining IOPP, Miriam worked for Blackwell Publishing and Wiley in a range of senior leadership roles, until January 2021 as Vice President and Managing Director, Editorial Management.

Miriam is a member of the STM Board, the global industry body for scholarly communications and a Trustee for the New Phytologist Foundation, a not-for-profit organisation dedicated to promoting research in plant biology. In addition, she has served on Research4Life's Executive Council since 2019, advising on strategic and operational issues.

Andy Macdonald, Chief People Officer, IOP Publishing

Andy Macdonald joined IOP Publishing in January 2023. He was previously Group HR Director at Jisc, where he led its first people strategy with a specific focus on a programme looking at 'the future of work'. Andy also led the development of a 'One Jisc Culture', founded on powerful guiding principles which are shaping the organisation's identity.
Andy is a fellow of the CIPD, with 30 years of experience. His career has spanned HR leadership roles across several sectors internationally, including financial services, telecoms, technology and medical services in both private and not-for-profit organisations.

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Adam Sewell joined IOP Publishing in February 2023. He was previously Chief Technology Officer at Metropolis, a group that specialises in business and consumer media and discount programmes. Prior to joining Metropolis, he was Chief Information Officer at the Copyright Licensing Agency from 2012, and Associate Director for Business Systems at Nature Publishing Group from 2001. He began his career in IT at Lane Clark and Peacock, a firm of Consulting Actuaries. Adam has a BEng in Telecommunications from Queen Mary and Westfield, University of London.

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He was previously at John Wiley & Sons Ltd where he spent 15 years and held a variety of senior sales positions. He has extensive experience of leading sales teams across a wide range of products and markets, most recently as Wiley's Europe, Middle East and Africa sales director responsible for library sales growth across the region.

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She is an internationally certified Transformative and Results Coach, Neuro Change Practitioner, NLP Coach and Practitioner.

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Philip's most recent publishing experience was as Executive Vice President, Research at John Wiley, where he was responsible for the company's global journals publishing and for related digital services for the research community. Prior to this, he led Wiley's publishing for the Humanities and Social Sciences. He began his publishing career at Blackwell's, where he was Director, Academic and Science Books, prior to Wiley's acquisition of the company.

Phil Clarke, Independent Non-Executive Director

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In his Executive career, Phil was Chief Operating Officer at The White Company responsible for Finance, I.T., Supply Chain and Business Change. He was also CFO at Ann Summers and Group CFO of the Selfridges Group.

Kersty Drinkwater, Independent Non-Executive Director

Kersty Drinkwater is an IOPP Board member and Business Advisor, and also sits on the IOP Audit and Risk Committee. Beyond her role as a Non-Executive for the IOPP and IOP, Kersty is the Group Director of Audit & Risk for Kingfisher plc, a FTSE 100 retail Group.

Her executive career includes roles in both professional services and industry. She has been a partner in PwC LLP and EY LLP, advising organisations across a broad range of sectors on how to effectively identify, manage and assure their key risks. Previously she has held risk and audit senior leadership roles in BP and G4S.

Kersty also chairs the Audit, Risk and Remuneration Committee for St Peters College, Oxford. Prior to this she was a member of the Audit, Risk and Scrutiny Committee for Oxford University.

Martin Freer, IOP Vice President of Science and Innovation, Trustee Non-Executive Director

Professor Martin Freer is a nuclear physicist, and Director of the Birmingham Energy Institute (BEI) at the University of Birmingham. He is also Director of the Energy Research Accelerator (ERA), which comprises eight internationally-renowned Midlands universities which are part of the Midlands Innovation partnership, together with the British Geological Survey.

Martin is former Director of the Birmingham Centre for Nuclear Education and Research, which he established in 2010. He has overseen the development of the BEI, helped establish Energy Capital and has co-led the establishment of the joint University of Birmingham–Fraunhofer Germany research platform. He led the development of the Birmingham Energy Innovation Hub and the co-development of Tyseley Energy Park in Birmingham.

In 2015 he co-led the BEI Commission "Doing Cold Smarter" chaired by Lord Teverson, and in 2012 he led the Policy Commission "Future of Nuclear Energy in the UK" chaired by Lord Hunt, he co-led the Policy Commission with Sir David King which saw the creation of Energy Innovation Zone in the West Midlands and in 2020 published a report on The Road to Low-Carbon Heat with the CBI chaired by Lord Billimoria. His main research area is the study of the structure of light nuclei, using nuclear reactions. He received the Friedrich Wilhelm Bessel Prize, Humboldt Foundation, in 2004 and the Rutherford Medal in 2010

Eefke Smit, Independent Non-Executive Director

Eefke Smit is Managing Director of the International Publishers Rights Organisation, which represents international STEM publishers in the collection and repartition of copyright fees. For many years she served as the Director of Standards and Technology for STM, the International Association of STM Publishers, to coordinate activities for STM members in the areas of technology developments and standards. Part of this were the annual STM Trends forecast, initiatives on research data, seamless access and authentication, Artificial Intelligence and Digital Preservation.

Eefke has been active in academic and professional publishing for more than 35 years (in physics, mathematics, computer science) and in electronic product development (Scopus, ScienceDirect). She holds a masters' degree in public administration and started her working life as a writer/ journalist on research and technology (in NRC Handelsblad).

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Published online: 27 March 2018

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