Jurnal Penelitian Fisika dan Aplikasinya (JPFA) *Volume 8, Issue 1, June 2018*
p-ISSN: 2087-9946 DOI: 10.26740/jpfa.v8n1.p10-16
e-ISSN: 2477-1775 http://journal.unesa.ac.id/index.php/jpfa

Research Article

Elemental and Infrared Characterization of Contaminants in Second-Hand Cotton Garments From Flea Markets In Valencia City, Bukidnon, Philippines

Marilou Auxtero Pedroso-Butanas [1,a] and Bienvenido Masirin Butanas Jr. [2,b]

[1] Clothing and Textile Laboratory, Department of Home Economics Education and Family Life,
College of Human Ecology, Central Mindanao University
University Town, Musuan, Maramag, Bukidnon, 8710, Philippines
[2] Material Science Laboratory, Department of Physics, College of Arts and Sciences, Central Mindanao University
University Town, Musuan, Maramag, Bukidnon, 8710, Philippines

e-mail: [a] marilou.butanas@cmu.edu.ph and [b] bien.butanas@gmail.com

Abstract

The use of Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and energy dispersive X-ray (EDX) characterizations have been indispensable techniques in distinguishing purity of the samples. These techniques give spectra that will be used to analyze the composition, morphology, purity, among others, of the material. One of its interesting applications is to assess elemental and chemical contaminations on second hand clothing. In this study, second hand (Ukay-Ukay) cotton garments from selected flea market sites in Valencia City, Bukidnon, Philippines were examined quantitatively for microbial and chemical contaminations by using FTIR, SEM, and EDX. The FTIR results obtained in both sites showed broad peaks at ~3336 cm^{-1} attributed to OH functional group, and absorption peaks at 2901.30 cm^{-1} associated to C-H bond, 1159.70 cm^{-1}, 1107.44 cm^{-1} and 1053.82 cm^{-1} attributed to the stretches of CO bond. All of them were characteristics of cotton material. We observed degradation of the cotton material on both sites evident in the decreasing intensity of OH stretching (at peaks around ~3334 cm^{-1} [site A] and ~3332 cm^{-1} [site B]) and C-O stretching (around ~1500-1700 cm^{-1}). These were due to the presence of microorganisms such as fungi (e.g. Aspergillus species). The degradation was also observed in the SEM results. Furthermore, peaks related to carboxylate contaminants were observed in both sites around ~1600 – 1800 cm^{-1} that may be caused by the exposure of the cotton garments in hydrochloric acid (HCl). In general, the characterization results on both sites indicated traces of microorganisms and that the second-hand cotton clothes were contaminated by hazardous chemicals.

Keywords: *infrared properties, second hand garments, Ukay-Ukay, chemical contaminants, cotton degradation*

Karakterisasi Elemen dan Infrared dari Kontaminan pada Garmen Katun Bekas dari Pasar Loak di Kota Valencia, Bukidnon, Filipina

Abstrak

Penggunaan karakterisasi Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), dan energy dispersive X-ray (EDX) telah menjadi teknik yang sangat diperlukan

dalam menentukan kemurnian sampel. Teknik-teknik tersebut memiliki spectra yang dapat digunakan untuk menganalisis komposisi, morfologi, kemurnian, dari material. Salah satu aplikasi menatik dari teknik-teknik tersebut untuk mengevaluasi elemen kontaminan dan kontaminan kimia pada baju bekas. Pada penelitian ini, garmen katun bekas (Ukay-Ukay) dari beberapa Pasar Loak di Kota Valencia, Bukidnon, Filipina dikaji kontaminannya (baik bakteri maupun bahan kimia) secara kuantitatif menggunakan FTIR, SEM, dan EDX. Hasil FTIR yang diperoleh dari kedua tempat menunjukkan puncak pada ~3336 cm^{-1} yang bersesuaian dengan grup fungsional OH dan puncak absorpsi pada 2901,30 cm^{-1} yang berasosiasi dengan ikatan C-H serta 1159,70 cm^{-1}, 1107,44 cm^{-1}, dan 1053.82 cm^{-1} yang bersesuaian dengan peregangan ikatan CO. Ketiganya merupakan karakteristik dari material katun. Kami mengamati degradasi dari material katun dari kedua tempat terjadi seiring dengan berkurangnya intensitas peregangan OH (pada puncak sekitar ~3334 cm^{-1} [lokasi A] dan ~3332 cm^{-1} [lokasi B]) dan peregangan C-O (sekitar ~1500-1700 cm^{-1}). Hal ini dikarenakan adanya mikroorganisme seperti jamur (misalnya Aspergillus). Degradasi juga dapat diamati pada hasil SEM. Lebih lanjut, puncak terkait dengan kontaminan carboxylate termati pada kedua tempat di sekitar ~1600 – 1800 cm^{-1} yang mungkin disebabkan oleh terpaparnya kain katun oleh asam sulfat (HCl). Secara umum, hasil karakteristik dari kedua tempat mengindikasikan jejak mikroorganisme dan baju katun bekas tersebut terkontaminasi oleh bahan kimia berbahaya.

Kata Kunci: *sifat inframetah, garmen bekas, Ukay-Ukay, kontaminan kimia, degradasi katun*

PACS: 68.37.Hk, 87.64.km, 89.20.Bb, 91.30.pd

Article History: Received: November 16, 2017 Decided to resubmit (Round 1): January 13, 2018
Revised (Round 1): March 14, 2018 Approved with minor revision: May 3, 2018
Accepted: June 6, 2018 Published: June 30, 2018

How to cite: Pedroso-Butanas MA and Butanas Jr. BM. Elemental and Infrared Characterization of Contaminants in Second-Hand Cotton Garments From Flea Markets In Valencia City, Bukidnon, Philippines. *Jurnal Penelitian Fisika dan Aplikasinya (JPFA)*. 2018; **8**(1): 10-16. DOI: https://doi.org/10.26740/jpfa.v8n1.p10-16.

I. INTRODUCTION

Clothing is a feature of nearly all human societies, aside to the fact that clothing is one of the basic human needs and substantially serves as protection from the hazardous elements. Its primary function is to improve the comfort of the wearer and enhances safety during hazardous activities. Today, it has become one of the most fascinating and expensive items (branded garments) in fashion industry. This leads consumers to divert their interest into second hand clothes.

In the Philippines, the common term of second hand garment is called "*Ukay-Ukay* or *Wag-Wag*". These garments were imported from various countries. According to Philippines Journal of Development [1], one of the core concepts in the market demand analysis was that of consumer surplus. However, clothing may become a source for growth of microorganisms [2,3] such as pathogenic or odor-generating bacteria and fungi that whenever in contact with human body bid an ideal environment for microbial growth since it provides oxygen, moisture and warmth [4]. Pathogens, bacteria (scabies, pediculosis, among others), fungal and nosocomial infections can be a possible disease that could be found and transferred through the clothes or even hospital uniforms usage [5-7].

There were studies that discussed contaminations in some clothes by chemical and biotic factors such as the study of Y. M.

Muthiani and colleagues [7]. They reported a variety of potential skin pathogens found in unwashed second hand under garments such as bras and panties, socks and towels. Interestingly, there was a study pointing out that imported clothes could be one source of carrying diseases and growing toxic chemicals and infectious pathogens as well as threats of biological and chemical attacks from terrorists to other country [8]. Recently, the presence of microbial flora in second hand garments (*Ukay-Ukay*) from flea markets in Valencia City, Bukidnon, Philippines was reported [9]. This leads to the idea that conducting elemental and chemical investigations in second-hand clothes is an opportunity to scrutinize if there can be traces on the spectra of any certain microorganism and hazardous chemicals rather than protection from wearing it.

Hence, in this research, the elemental and chemical characteristics of second-hand cotton garments bought from the selected flea markets in Valencia City, Bukidnon, Philippines was investigated for possible traces of microorganisms and hazardous chemicals using Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) spectroscopy. Moreover, there is no existing research conducted in the Philippines on the chemical contaminations of second hand garments by using these techniques especially in Valencia City, Bukidnon, Philippines.

II. RESEARCH METHOD

Sample Preparation

Based on the site observations and interviews, two sampling sites referred to this study as sites A and B were identified as the main source (seller) of second-hand cotton clothes in Valencia City, Bukidnon, Philippines.

The samples were classified as to the consumer demand usage such as shirt/blouses but limited to cotton fabric for sampling control purposes.

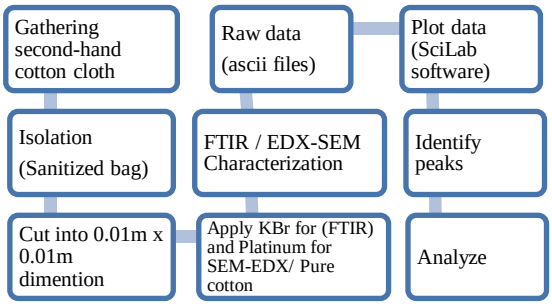

Figure 1. Schematic Flow Chart of Sample Collection, Preparation, and Characterization

The second-hand cotton fabrics bought from selected sites in Valencia City, Bukidnon, were placed to sterile polyethylene bag with desiccant silica gel. Portion of the cloth was cut into *0.01 m x 0.01 m* dimension for FTIR, SEM and EDX characterizations.

FTIR Characterization

The *0.01 m x 0.01 m* dimension of cloth was being coated with potassium bromide (KBr) to make the sample transparent to infrared light and was scanned at wavenumber range *4000 – 500* cm^{-1} using Perkin Elmer Spectrum 100 FTIR Spectrometer for IR analysis and identification. The raw data were plotted using SciLab software [10]. Then the absorption peaks were identified through comparison with standard reference materials

SEM-EDX Characterizations

The *0.01 m x 0.01 m* dimension of cloth samples was coated with Platinum to reduce surface charging. Then, surface morphology of the second-hand clothes samples was obtained using scanning electron microscope (JEOL Model: JSM-*6510*) at an accelerating voltage of *20 kV* with 0.3 mm bar magnification. On the other hand, EDX spectra were obtained during SEM

characterization (SEM coupled with EDX). Atomic percentage of each element present was recorded to determine the major elements that composes the samples.

III. RESULTS AND DISCUSSION

Table 1 shows the elemental compositions of the samples in sites A and B. Site A sample was observed to contain carbon, oxygen and chlorine. We note that both samples (sites A and B) contain chlorine. Pure cotton material does not contain chlorine. This may suggest that both samples were exposed to chlorine before display in every site.

Furthermore, it was remarkable to observe elements such as calcium, sodium and aluminum in the sample found in site B. Calcium, sodium and aluminum elements were derivatives of chemicals introduced to the second-hand cotton sample.

Table 1. Elemental composition of the second-hand cotton sample with atomic percentage.

Element	Site A (Atomic %)	Site B (Atomic %)
Carbon	59.63	61.44
Oxygen	40.28	38.08
Chlorine	0.09	0.09
Calcium	0.00	0.10
Sodium	0.00	0.22
Aluminum	0.00	0.07

FTIR and SEM Analyses

Figure 2 shows the superimposed FTIR spectra of the second-hand cotton samples (obtained in sites A and B). The spectra show broad bands, characteristic of cellulose (main component of cotton fiber), at *~3334 cm* $^{-1}$ (site A sample) and *~3332 cm* $^{-1}$ (site B sample) ascribed to *OH* functional stretching [2,11,13,15,17].

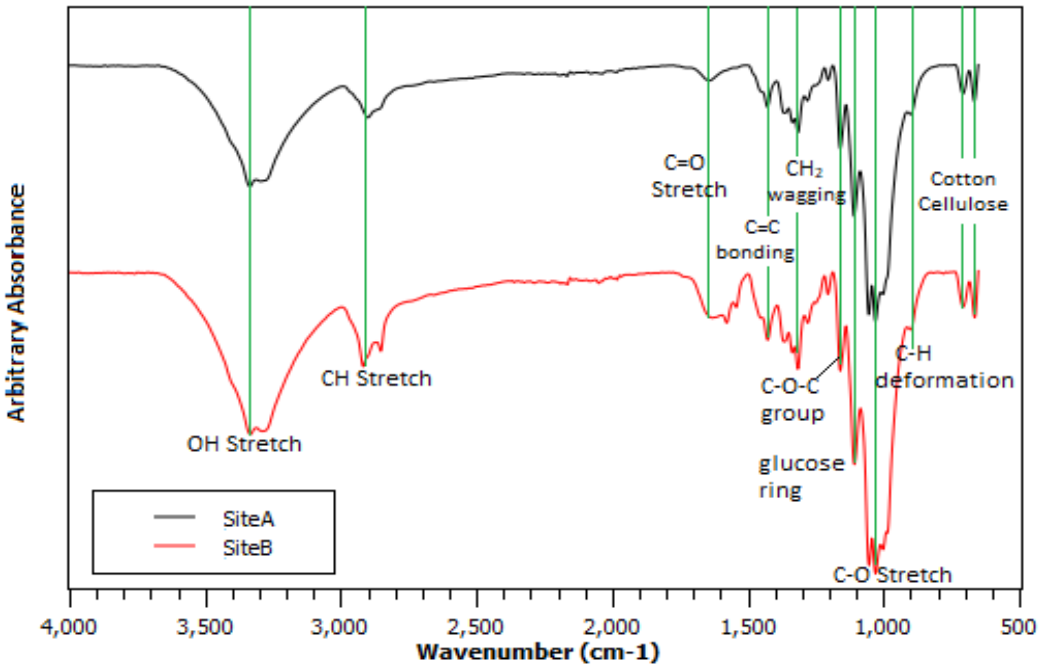

Figure 2. FTIR Spectra of the Samples of Cotton Second Hand Garment Obtained in Site A (Black) and Site B (Red).

Moreover, there are absorption peaks at *~2899 cm* $^{-1}$ (site A sample) and *~2917 cm* $^{-1}$ (site B sample) associated to *C-H* bond stretching, which may indicate the presence of

waxes and oils [12,14]. The C-H bond stretching peaks decreased their intensity as you go from sites B to A indicating that the sample obtained in site A has degraded more than in site B. The hydrogen bonds, methyl and methylene of cellulose had some fraction which could make the organisms attack the cellulose easily [13,17-20]. This was reasonable since microorganisms preferred environment with hydrogen-bonded water molecules. Likewise, characteristic peaks of cotton were observed at *~1159 cm^{-1}, ~1108 cm^{-1}, ~1054 cm-^{1}* (site A sample) and *~1159 cm^{-1}, ~1107 cm^{-1}, ~1053 cm^{-1}* (site B sample), which were attributed to glucose ring vibrations, C-O stretching modes, etc. [15].

The former peaks represent the antisymmetric stretching of the C-O-C groups in the cellulose [13,15]. Another absorption peak for cellulose was observed at *~1427.71cm^{-1}* associated to CH_2 bending [15]. We noticed that the bands around the range *~1500-1700 cm^{-1}* for C-O stretching decreased expressively which may entail degradation like the trend of FTIR data reported by Li, Frey, and Browning [13]. This degradation may be associated to the presence of microorganisms such as fungi (e.g. *Aspergillus* species*)* [16]. This result complements with Samaniego and Elumba [9] as they recovered and identified several microorganisms found in the second-hand garments in the flea markets of Valencia City, Bukidnon, Philippines.

Indeed, Figures 3 and 4 showed that the cotton clothes started to degrade. The fibers were disassembled, and the knitting pattern became irregular.

On the other hand, there were peaks related to the presence of carboxylate groups (*~1600-1800 cm^{-1}*) which suggest that the samples were exposed to HCl [11]. The presence of chlorine was observed in the EDX analysis as reflected in Table 1. These carboxylates were impurities of the cotton fabric [11] which can be removed normally through washing.

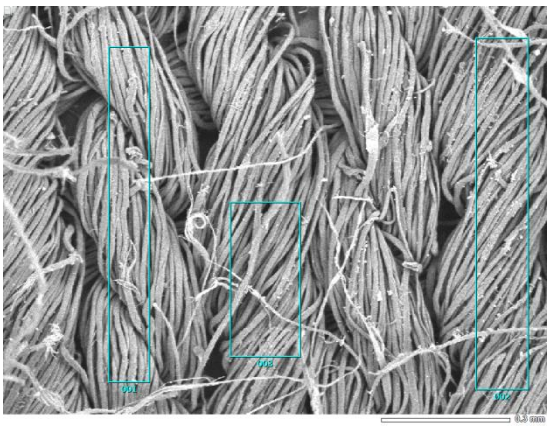

Figure 3. SEM Photomicrograph of The Cotton Sample Obtained in Site A.

Other information such as peaks around *~1314 cm^{-1}, ~1315 cm^{-1}* (sites A and B samples) associated to CH_2 wagging [15] and *~665 cm^{-1}* (site A sample), *663 cm^{-1}* (site B sample) which were related to the vibration modes of cellulose [17] were observed. Likewise, we observed C-H deformation peaks around (*~900 - 800 cm^{-1}*) in both sample sites [15]. Finally, the bands around the finger print region (*~800 - 600 cm^{-1}*) were difficult to interpret but mostly belong to cotton cellulose as reported by Sugiyama, Person, and Chanzy. [17].

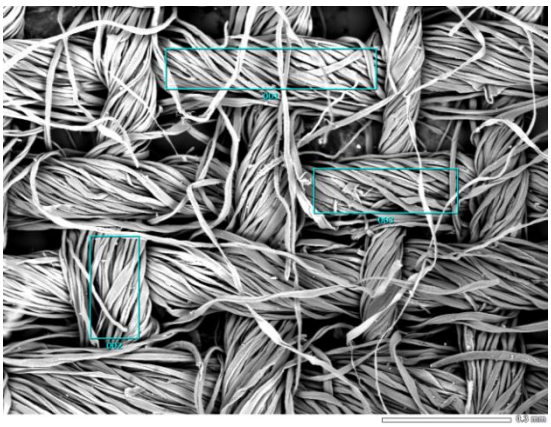

Figure 4. SEM Photomicrograph of The Cotton Sample Obtained in Site B.

IV. CONCLUSION

In this study, we have shown that the EDX and FTIR results conform to the elemental and chemical compositions of the cotton fabric. However, EDX showed elemental contaminants in the samples found in both sites A and B. Site B was found to have the most numbered contaminants. The elemental contaminants observed were chlorine, aluminum, calcium and sodium. Furthermore, FTIR results showed vibrations of chemical compounds associated to the presence of contaminants such as carboxylate.

Moreover, the samples (*Ukay-Ukay*) of cotton fabric started to degrade as shown in SEM photomicrographs in (Figures 3 and 4). The degradation of the cotton material was also evident in the decreasing intensity of OH stretching (at peaks around *~3334 cm* $^{-1}$ [site A sample], *~3332 cm* $^{-1}$ [site B sample]) and C-O stretching (around *~1500-1700 cm*$^{-1}$) on both sites found in Figure 2. Finally, the degradation of the cotton material suggested the presence of microorganisms such as fungi (e.g. *Aspergillus* species).

Seeing these microorganisms on the surface of the cotton clothes at higher magnification via SEM will be a nice future direction of research.

ACKNOWLEDGMENT

This research was supported financially by Central Mindanao University through grant number R-0035 of the University Research and Extension unit.

REFERENCES

[1] Abueg LC. The Economics of Secondhand Retail Trade: An Analysis of the Market for Ukay-Ukay. *Philippine Journal of Development*. 2005; **32**(1): 53-77. Available from: https://dirp4.pids.gov.ph/ris/pjd/pidspjd05-1ukay.pdf.

[2] Fijan S and Turk SS. Hospital Textiles, Are They a Possible Vehicle for Healthcare-Associated Infections? *International Journal of Environmental Research and Public Health*. 2012; **9**(9): 3330-3343. DOI: https://doi.org/10.3390/ijerph9093330.

[3] Wiener-Well Y, Galuty M, Rudensky B, Schlesinger Y, Attias D, and Yinnon AM. Nursing and Physician Attire as Possible Source of Nosocomial Infections. *American Journal of Infection Control*. 2011; **39**(7): 555-559. DOI: https://doi.org/10.1016/j.ajic.2010.12.016.

[4] El-Shishtawy RM, Asiri AM, Abdelwahed NAM, and Al-Otaibi MM. In situ Production of Silver Nanoparticle on Cotton Fabric and Its Antimicrobial Evaluation. *Cellulose*. 2011; **18**: 75-82. DOI: https://doi.org/10.1007/s10570-010-9455-1.

[5] Callaghan I. Bacterial Contamination of Nurses' Uniforms: A Study. *Nursing Standard*. 1998; **13**(1): 37-42. DOI: https://doi.org/10.7748/ns1998.09.13.1.37.c2525.

[6] South Australia Public Health Fact Sheet. *Second Hand Goods: A Guide for Consumers.* Website. Available from: http://www.helth.sa.gov.au./PEHS/PDF-fil0es/ph-fs-consumers-secondhand.pdf. [accessed January 2009].

[7] Muthiani YM, Matiru VN, and Bii C. Potential Skin Pathogens on Second Hand Clothes and the Effectiveness of Disinfection Methods. *Scientific Conference Proceedings*. Jomo Kenyatta University of Agriculture and Technology. 2010; 144 – 162. Available from: http://journals.jkuat.ac.ke/index.php/jscp/article/view/688.

[8] Liu N, Sun G, and Zhu J. Photo-induced Self-cleaning Functions on 2-Anthraquinone Carboxylic Acid Treated Cotton Fabrics. *Journal of Materials Chemistry*. 2011; **21**: 15383-15390. DOI: https://doi.org/10.1039/C1JM12805A.

[9] Samaniego LG and Elumba E. Microbial Flora in Ukay-Ukay from Flea Markets in

Valencia City, Bukidnon. *CMU Journal of Science*. 2016; **20** (3): 32-53. Available from: http://www.cmu.herdin.ph/index.php/component/herdin/?view=research&cid=62255.

[10] Scilab. *Homepage of Scilab*. Available from: http://scilab.com.

[11] Chung C, Lee M, and Choe EK. Characterization of Cotton Fabric Scouring by FT-IR ATR Spectroscopy. *Carbohydrate Polymers*. 2004; **58**(4): 417-420. DOI: https://doi.org/10.1016/j.carbpol.2004.08.005.

[12] Himmelsbach DS, Akin DE, Kim J, and Hardin IR. Chemical Structural Investigation of the Cotton Fiber Base and Associated Seed Coat: Fourier-Transform Infrared Mapping and Histochemistry. *Textile Research Journal*. 2003; **73**(4): 218-288. DOI: https://doi.org/10.1177/004051750307300401.

[13] Li L, Frey M, and Browning KJ. Biodegradability Study on Cotton and Polyester Fabrics. *Journal of Engineered and Fabrics*. 2010; **5**(4): 42-51. Available from: https://www.jeffjournal.org/papers/Volume5/5-4-6Frey.pdf.

[14] Allen A, Foulk J, and Gamble G. Preliminary Fourier-Transform Infrared Spectroscopy Analysis of Cotton Trash. *The Journal of Cotton Science*. 2007; **11**(1):68-74. Available from: https://pubag.nal.usda.gov/download/8608/PDF.

[15] Blackwell J, Vasko PD, and Koening JL. Infrared and Raman Spectra of the Cellulose From the Cell Wall of Valonia Ventricosa. *Journal of Applied Physics*. 1970; **41**(11): 4375-4379. DOI: https://doi.org/10.1063/1.1658470.

[16] Fischer G, Braun S Thissen R, and Dott W. FT-IR Spectroscopy as a Tool for Rapid Identification and Intra-species Characterization of Airborne Filamentous Fungi. *Journal of Microbiological Methods*. 2006; **64**(1): 63-77. DOI: https://doi.org/10.1016/j.mimet.2005.04.005.

[17] Sugiyama J, Person J, and Chanzy H. Combined Infrared and Electron Diffraction Study of the Polymorphism of Native Cellulose. *Macromolecules*. 1991; **24**(9): 2461-2466. DOI: https://doi.org/10.1021/ma00009a050.

[18] Michell AJ. Second Derivative FTIR Spectra of Native Cellulose. *Carbohydrate Research*. 1990; **197**: 53-60. DOI: https://doi.org/10.1016/0008-6215(90)84129-I.

[19] Michell AJ. Second-Derivative FTIR Spectra of Native Celluloses From Valonia and Tunicin. *Carbohydrate Research*. 1993; **241**: 47-54. DOI: https://doi.org/10.1016/0008-6215(93)80093-T.

[20] Kokot S, Czarnik-Matusewicz B, and Ozaki Y. Two-Dimensional Correlation Spectroscopy and Principal Component Analysis Studies of Temperature-Dependent IR Spectra of Cotton-Cellulose. *Biopolymers*. 2002; **67**: 456-469. DOI: https://doi.org/10.1002/bip.10163.