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Electric Static Charge and Friction Coefficient of Head Scarf Textiles Sliding Against Hair and Skin

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Abstract

Friction coefficient and electrification of textiles are the main factors that specify the quality of cloths. The friction of textiles can be broadly evaluated by the touch of human skin to feel the slipperiness and smoothness. Voltage generated from electrification of the human body by sliding of the head scarf textiles against skin and hair should not exceed certain limit to avoid serious health problems. In the present work, electric static charge generated from the friction of hair and skin against head scarf of different textiles materials as well as friction coefficient have been measured. The experimental results showed that, crape displayed the highest value of friction coefficient when sliding against skin followed by flax, chiffon, cotton, polyacrylonitrile, satin and polyester. The tested types of hair showed different friction behaviour, where African hair showed the lowest friction when slid against crape, chiffon, polyacrylonitrile and flax. Caucasian hair displayed the lowest friction with cotton, jil, and satin. Asian hair gave higher friction with polyacrylonitrile, flax, jil, polyester and satin. The safe level of charge was gained by skin and hair when slid against cotton, jil and chiffon, while the highest voltage values were recorded for polyester, polyacrylonitrile, flax and crape. Skin and hair gained much higher charge than scarf textiles. Caucasian hair gained the highest voltage up to 9500 volts when slid against polyester followed by satin, crape, flax, polyacrylonitrile. It is known that, the relatively high friction as well as high voltage may cause injuries and blisters of skin. Proper selection of textiles that can minimize the generation of electric static charge is desired. Cotton textiles can minimize the generated voltage and provide acceptable values of friction coefficient.

Keywords

Electric Static Charge, Friction, Head Scarf Textiles, Hair, Skin

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1. Introduction

The increased interest in investigating the electrostatic effects was forced by the wide use of polymeric fibers in textile industry. Charging of the human body during contact on the floor was investigated. The safe body voltage should be less than 100 volts, [1]. Therefore, the effect of polymeric textiles on generating electric static charge should be studied to avoid the risk of electric static indoors.

Little attention has been considered to the electric static charge of hair although these properties are very sensitive to the friction between hair and head scarf textiles. Hair has a tendency to develop static charge when rubbed with dissimilar materials like human skin and textiles, [2 - 4]. It was found that hair is charged by a macroscale triboelectric interaction between the surface and the rubbing element.

It was found that, nylon head scarf when sliding against hair showed relatively lower friction coefficient than that observed for polyester and cotton scarf. Asian hair displayed higher friction values than African hair, [5]. Electric static charge measured in voltage represented relatively lower values. This behaviour may be attributed to the ranking of the

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rubbing materials in the triboelectric series where the gap between human hair and nylon is smaller than the gap between hair and cotton as well as hair and polyester.

It was revealed that, electric static charge generated on the skin and the tested textiles increased with increasing normal load, [6]. Friction between Caucasian hair and polyester scarf generated the highest electric static charge followed by African and Asian hairs when slid against cotton. Besides, sliding of polyacrylonitrile against skin displayed higher voltage than that generated from cotton and polyester. While, sliding of African hair against polyacrylonitrile textiles recorded the highest values of voltage.

Several studies have looked at static charging characteristics of hair, [7, 8]. The charge distribution was characterized by measuring the surface potential of the control. The rubbing load was progressively increased, and the effect of this increase on the charge build up was assessed.

African, Asian and Caucasian hairs are often distinguished by their curly, straight and wavy hair features, respectively, [9 – 12]. The mechanical properties of human hair including Young's modulus and hardness have been investigated, [13 – 22]. The electrostatic properties have been investigated, [23], where surface potential imaging was used to determine the electrostatic.

The electrostatic charge generated from the friction of polytetrafluoroehylene (PTFE) textiles was tested to propose developed textile materials with low or neutral electrostatic charge which can be used for industrial application especially as textile materials, [24]. The results showed that addition of wool, cotton and nylon fibers remarkably decreases the electrostatic discharge and consequently the proposed composites will become environmentally safe textile materials.

The present work discusses the friction and electric static charge generated from the sliding of head scarf of different materials against skin and hair.

2. Experimental

Experiments were carried out using a test rig designed and manufactured to measure the friction coefficient between the textiles and the skin and hair through measuring the friction and normal forces. The tested textiles are adhered to the base supported by two load cells, the first could measure the horizontal force (friction force) and the second could measure the vertical force (normal force). Friction coefficient is determined by the ratio between the friction and the normal force. The arrangement of the test rig is shown in Fig. 1. Skin of the back hand as well as African, Asian and Caucasian hair were loaded against head scarf textiles and slid under different load values. The tested hair was stretched on the upper surface of wooden cube of 50 × 50 × 50 mm^3, Fig. 2.

Electric static charge generated by the sliding of skin and hair against head scarf textiles was measured. The experiments simulate the friction displayed by the sliding of textiles against skin and hair. The electrostatic fields (voltage) measuring device (Ultra Stable Surface DC Voltmeter) was used to measure the electrostatic charge (electrostatic field) for test specimens, Fig. 3. Readings are normally done with the sensor 25 mm apart from the surface being tested.

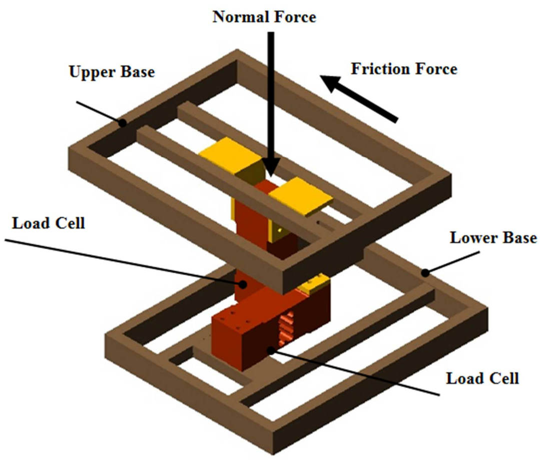

Fig. 1. Arrangement of test rig.

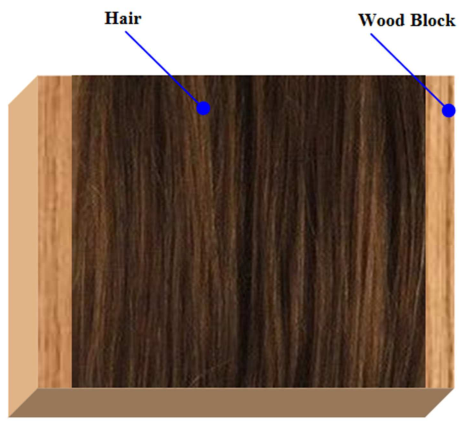

Fig. 2. Human Hair adhered on wooden block.

Fig. 3. Electrostatic field measuring device.

3. Results and Discussion

When two different surfaces are sliding against each other, one surface will gain some electrons from the other surface. The surface that gains electrons will be negatively charged, while the other surface will have the same number of positive charge, this behaviour is illustrated in Fig. 4. The intensity of the charge depends on the rank of the material in the triboelectric series. Electric static charge generated on cotton head scarf when sliding against skin and hair is shown in Fig. 5. It can be noticed that, voltage showed relatively low values which is considered as safe level of charge. Skin showed the highest voltage (96 volts) followed by Asian, African and Caucasian hair. Also, skin displayed the highest friction coefficient, while Caucasian hair showed the lowest one. Electric static charge generated on skin and hair as well as friction coefficient are shown in Fig. 6. Caucasian hair gained relatively high voltage (950 volts) followed by African hair (610 volts) and Asian hair (140 volts). Those values are much higher than that gained by head scarf. It seems that the charge generated on cotton textiles decays very rapidly due to the higher conductivity of cotton. The sliding behaviour of skin against textile is shown in Fig. 7.

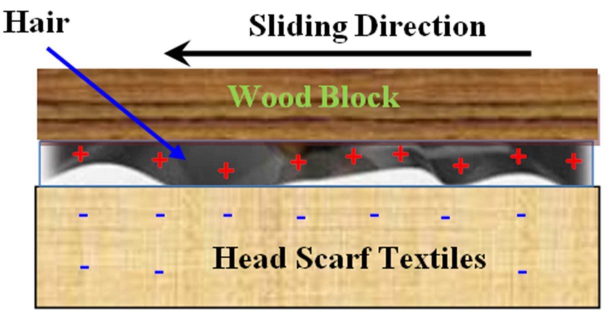

Fig. 4. Sliding of hair against head scarf textiles.

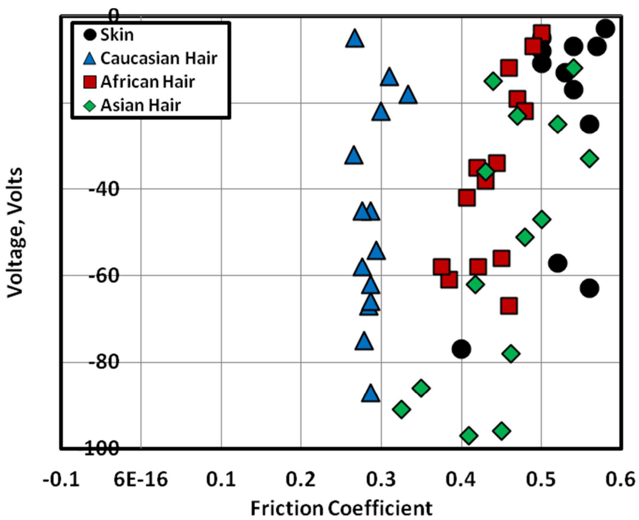

Fig. 5. Electric static charge generated on cotton head scarf when sliding against skin and hair.

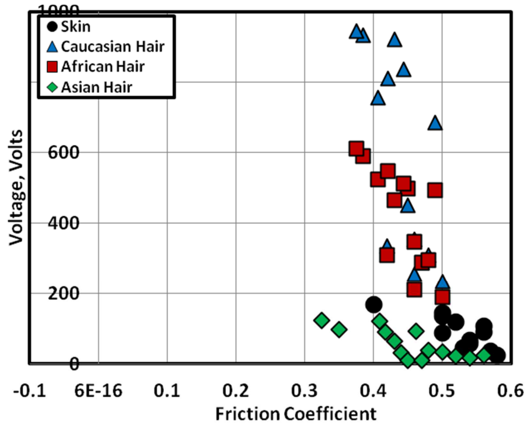

Fig. 6. Electric static charge generated on skin and hair when sliding against cotton head scarf.

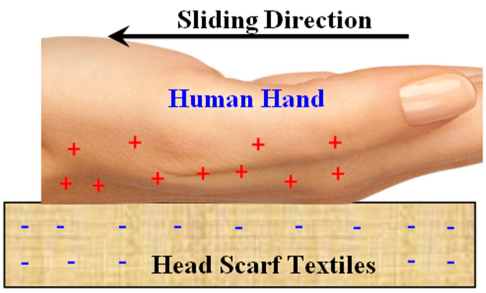

Fig. 7. Sliding of skin against head scarf textiles.

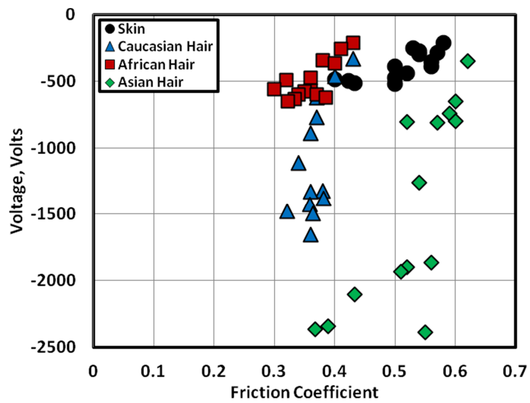

Fig. 8. Electric static charge generated on polyacrylonitrile head scarf when sliding against skin and hair.

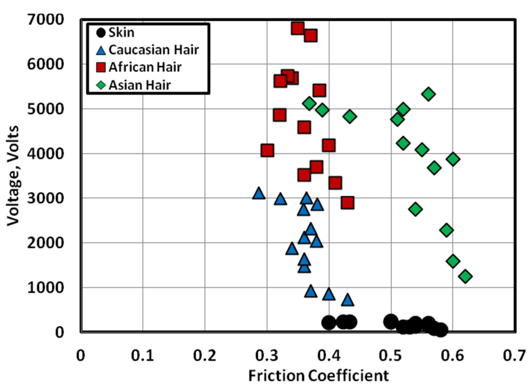

Fig. 9. Electric static charge generated on skin and hair when sliding against polyacrylonitrile head scarf.

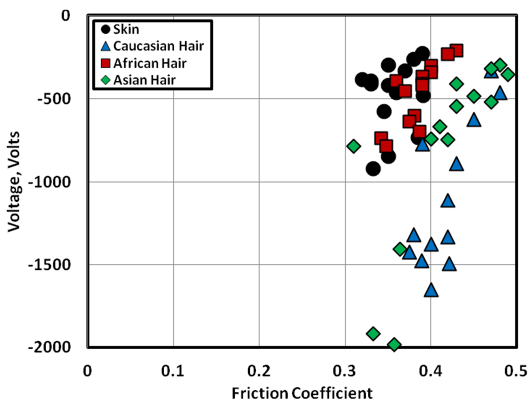

Fig. 10. Electric static charge generated on polyester head scarf when sliding against skin and hair.

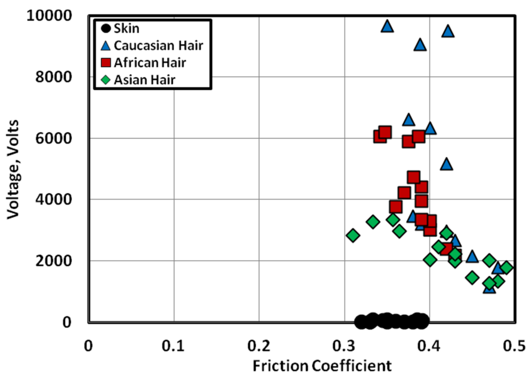

Fig. 11. Electric static charge generated on skin and hair when sliding against polyester head scarf.

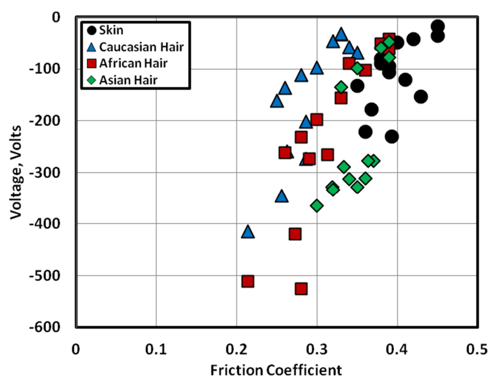

Fig. 12. Electric static charge generated on satin head scarf when sliding against skin and hair.

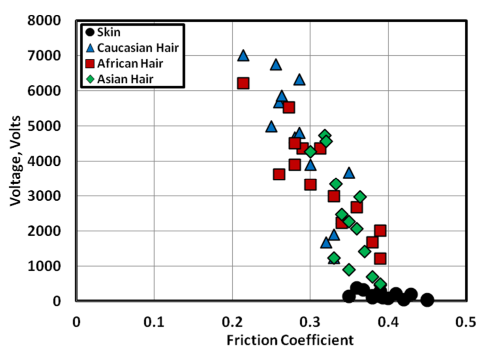

Fig. 13. Electric static charge generated on skin and hair when sliding against satin head scarf.

Figure 8, 9 shows the relationship between electric static charge generated from sliding of polyacrylonitrile head scarf against skin and hair. Asian hair caused the highest value of friction followed by skin, Caucasian and African hair. The friction values are higher than that displayed by cotton scarf. Electric static charge gained by scarf when slid against Asian hair reached -2400 volts followed by Caucasian hair (-1700 volts) and African hair (-700 volts). Skin displayed the lowest voltage (-550 volts). Those values are exceeding the safe limit. Voltage generated on skin and hairs showed very high values reached to 6900 volts for African hair, 5300 volts for Asian hair and 3100 volts for Caucasian hair, while voltage generated on skin did not exceed 200 volts due to its good electrical conductivity.

Friction coefficient displayed by polyester head scarf sliding against skin and hair showed lower values than that observed for cotton and polyacrylonitrile, Figs 10, 11, where the maximum values did not exceed 0.58. Electric static charge generated n polyester head scarf recorded -2000, -1700, -800 and -900 for Asian, Caucasian, African and skin respectively. Caucasian hair gained very high voltage (9800 volts) followed by African hair (6000 volts) and Asian hair (3000). Skin gained relatively low voltage (250 volts). Based on this observation, it can be recommended to avoid using polyester as head scarf textiles.

The results of the measurements of friction coefficient and electric static charge generated on satin scarf are shown in Figs. 12, 13. It is seen that satin gave lower friction than polyester due to its satin weaves, where African hair showed the lowest values followed by Caucasian, African and skin. Voltage generated on satin scarf was very low compared to that shown by polyester, where the highest voltage reached -520 volts for African hair. Higher voltage values were recorded for charge gained by skin and hair. Those values were 7000, 6200, 4800 and 375 volts for Caucasian, African, Asian and skin respectively.

Flax textile showed relatively high friction coefficient for skin followed by Asian, Caucasian and African hair. The highest friction recorded for skin was 0.63, Figs. 14, 15. Voltage generated on flax scarf represented unsafe values which were -2600, -2250 and 1400 volts for African, Asian and Caucasian hair respectively, while for skin was -1200 volts. Voltage generated on hairs showed slight increase, while skin displayed only 300 volts.

Jil head scarf displayed reasonable values of friction coefficient, where the values were 0.56, 0.53, 0.49 and 0.43 for Asian hair, skin, African hair and Caucasian hair respectively, Figs. 16, 17. Voltage generated on the jil scarf as well as skin and showed the lowest values. The results suggest jil as textile suitable for head scarf that can minimize the generation of electric static charge.

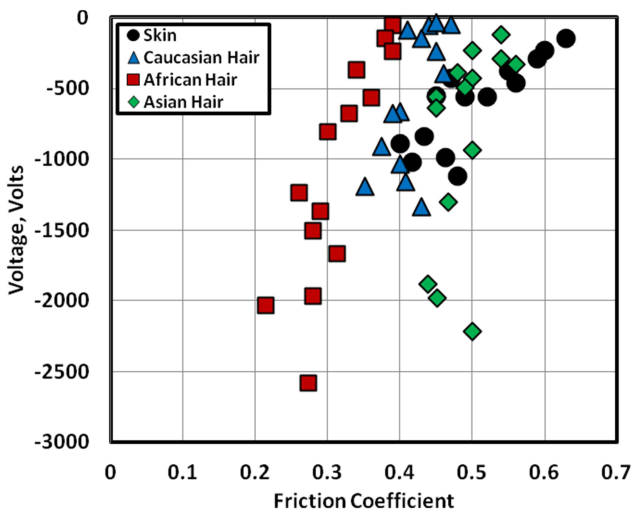

Fig. 14. Electric static charge generated on flax head scarf when sliding against skin and hair.

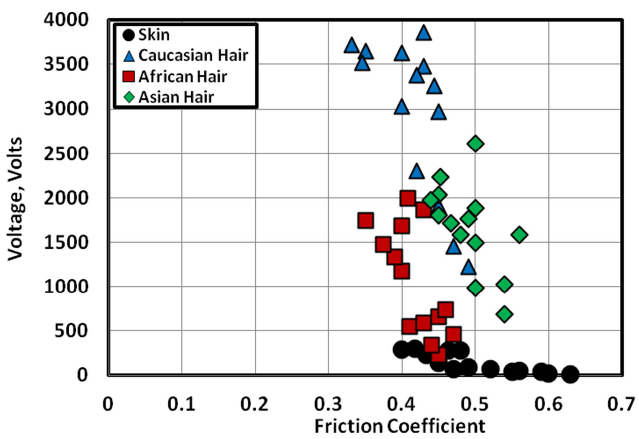

Fig. 15. Electric static charge generated on skin and hair when sliding against flax head scarf.

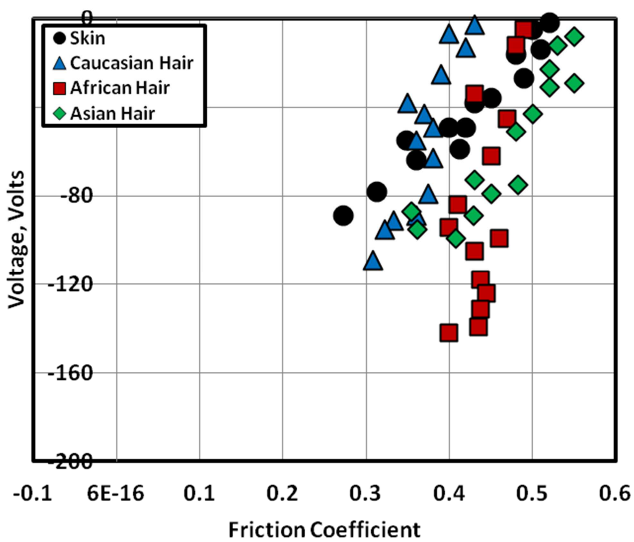

Fig. 16. Electric static charge generated on jil head scarf when sliding against skin and hair.

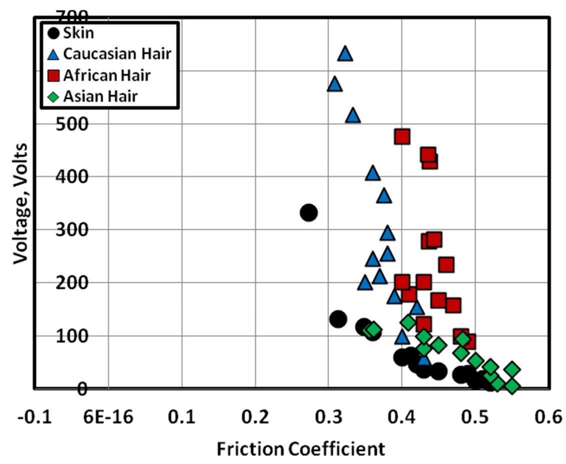

Fig. 17. Electric static charge generated on skin and hair when sliding against jil head scarf.

Chiffon displayed relatively higher friction values when sliding against skin followed by Asain, African and Caucasian hair, Figs. 18, 19. Electric static charge generated on the surface of chiffon scarf showed safe values, but that generated on hair recorded relatively higher values. Skin showed the lowest voltage which did not exceed 71 volts. Caucasian hair displayed the highest voltage (1160 volts) followed by African hair (600 volts) then Asian hair (520 volts).

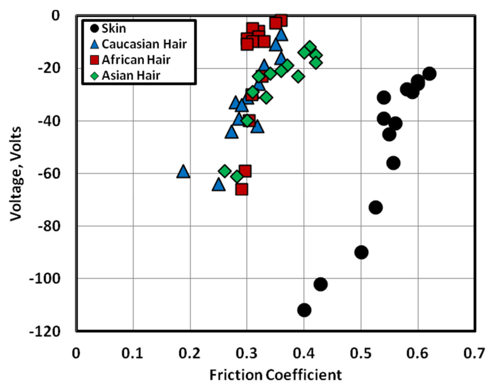

Fig. 18. Electric static charge generated on chiffon head scarf when sliding against skin and hair.

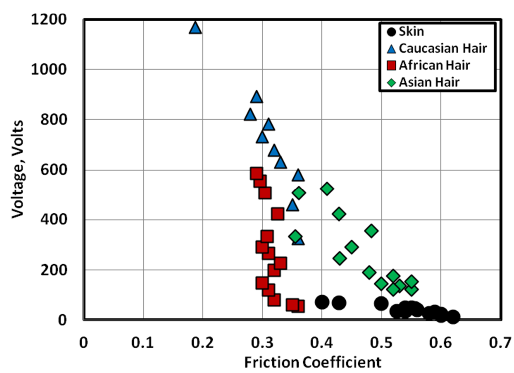

Fig. 19. Electric static charge generated on skin and hair when sliding against chiffon head scarf.

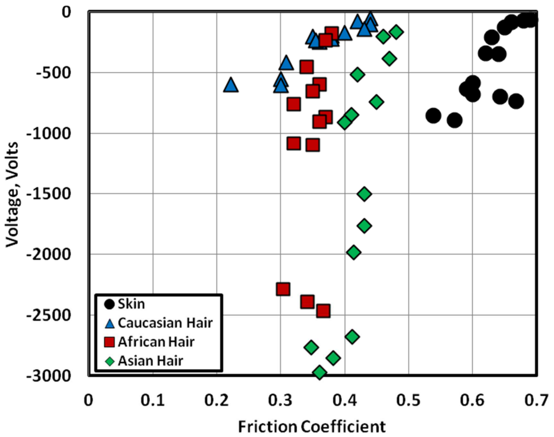

Fig. 20. Electric static charge generated on crape head scarf when sliding against skin and hair.

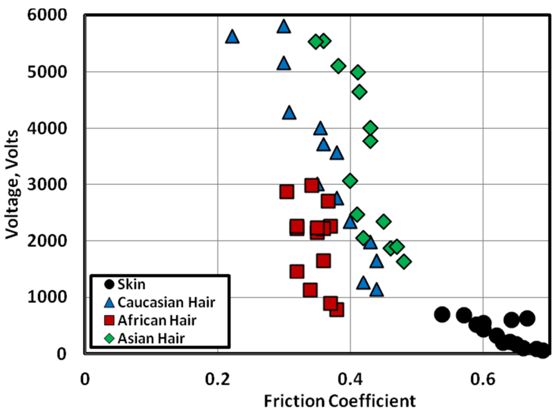

Fig. 21. Electric static charge generated on skin and hair when sliding against crape head scarf.

Crape textiles recorded the highest friction coefficient among the tested materials, Figs. 20, 21, due to its gauzy texture of the crimpy appearance. The maximum friction coefficient was 0.69 when crape slid on skin. The high friction value may be considered as friction-induced injuries to skin such as blistering, [25, 26]. Friction between the skin and rough textiles may cause injuries and blisters. Voltage generated on crape scarf gained negative charge of relatively high values of -3300, -2500 and -700 volts for Asian, African and Caucasian hair respectively. Skin caused -900 volts. Higher values of voltage of 5800, 5600 and 3000 volts were generated on Caucasian, Asian and African hair respectively, while skin gained 700 volts.

4. Conclusions

1. Electric static charge generated on cotton head scarf when sliding against skin and hair showed the safe level of charge. Skin showed the highest voltage (96 volts) followed by Asian, African and Caucasian hair. Caucasian hair gained relatively high voltage (950 volts) followed by African hair (610 volts) and Asian hair (140 volts). Those values are much higher than that gained by head scarf. Also, skin displayed the highest friction coefficient, while Caucasian hair showed the lowest one.

2. Polyacrylonitrile sliding against Asian hair caused the highest value of friction followed by skin, Caucasian and African hair. The friction values are higher than that displayed by cotton scarf. Very high voltage gained by scarf when slid against Asian hair followed by Caucasian and African hair, while skin displayed the lowest voltage. Voltage generated on skin and hairs showed very high values reached to 6900 volts for African hair, 5300 volts for Asian hair and 3100 volts for Caucasian hair.

3. Friction coefficient displayed by polyester head scarf sliding against skin and hair showed lower values than that observed for cotton and polyacrylonitrile. Voltage generated on polyester recorded high values. Caucasian hair gained very high voltage (9800 volts) followed by African hair (6000 volts) and Asian hair (3000 volts). Skin gained relatively low voltage (250 volts).

4. Satin gave the lowest friction, where African hair showed the lowest values followed by Caucasian, African and skin. Voltage generated on satin scarf was very low compared to that shown by polyester. Higher voltage values were recorded for charge gained by skin and hair.

5. Flax textile showed relatively high friction coefficient for skin followed by Asian, Caucasian and African hair. Voltage generated on flax scarf represented unsafe values, while that generated on hairs showed very low values.

6. Jil head scarf displayed reasonable values of friction coefficient. Voltage generated on jil scarf as well as skin and hair showed the lowest values. The results suggest jil as textile suitable for head scarf that can minimize the generation of electric static charge.

7. Chiffon displayed relatively higher friction values. Voltage generated on the surface of chiffon showed safe values, but that generated on hair recorded relatively higher values. Skin showed the lowest voltage, while Caucasian hair displayed the highest voltage followed by African hair and Asian hair.

8. Crape textiles recorded the highest friction coefficient among the tested materials. Voltage generated on crape gained negative charge of relatively high values. Higher values of voltage were generated on Caucasian, Asian and African hair respectively.

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