



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: A
MECHANICAL AND MECHANICS ENGINEERING
Volume 14 Issue 8 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Impact of the Smart Textile on the High Level Sport Performance and Patient Behavior in Medicine

By R. Taiar

Université de Reims, France

Abstract- In the present study we developed several proto types which will be intended for the high level sport performance like swimming, triathlon, skiing and medicine. 6 innovative fabric proto types were developed in the aim to answer to the exigencies of the high level sport and medicine. We opted for the high-tech polyamide fiber; in the production of the textile. These innovative processes will be adapted for medical use. The medical example relates the contribution of fabrics in helping hemiplegic patients float on the water's surface. This water rehabilitation will help decrease scabs on hemiplegics by reducing the contact between the body and the wheelchair for instance. Physicochemical analysis has been done for the comparison of the different sample. No significant difference was observed between the textiles in static and dynamic behavior ($P > 0.05$). In the future work the solution that we consider rests on the implementation of a data-processing platform of virtual prototyping in order to simulate all the stages of clothes industry and to lead to the most powerful model of textile specification within times much shorter. CFD (Computational Fluid Dynamics) and human modelization were used for the simulation and were compared to the experimental data for the validation.

Keywords: *wettability, static impact angle, dynamic impact angle, textiles, biomechanics.*

GJRE-A Classification : *FOR Code: 091399*



Strictly as per the compliance and regulations of:



Impact of the Smart Textile on the High Level Sport Performance and Patient Behavior in Medicine

R. Taiar

Abstract- In the present study we developed several prototypes which will be intended for the high level sport performance like swimming, triathlon, skiing and medicine. 6 innovative fabric prototypes were developed in the aim to answer to the exigencies of the high level sport and medicine. We opted for the high-tech polyamide fiber; in the production of the textile. These innovative processes will be adapted for medical use. The medical example relates the contribution of fabrics in helping hemiplegic patients float on the water's surface. This water rehabilitation will help decrease scabs on hemiplegics by reducing the contact between the body and the wheelchair for instance. Physicochemical analysis has been done for the comparison of the different simple. No significant difference was observed between the textiles in static and dynamic behavior ($P > 0.05$). In the future work the solution that we consider rests on the implementation of a data-processing platform of virtual prototyping in order to simulate all the stages of clothes industry and to lead to the most powerful model of textile specification within times much shorter. CFD (Computational Fluid Dynamics) and human modelization were used for the simulation and where compared to the experimental data for the validation.

Keywords: wettability, static impact angle, dynamic impact angle, textiles, biomechanics.

I. INTRODUCTION

The textile fibers are of vegetable origin, animal, mineral or chemical (artificial or synthetic). The synthetic fibers or yarns are realized from polymers obtained by synthesis of chemical compounds. The artificial fibers are manufactured, inter alia, starting from regenerated cellulose. The textile innovation in high level sport is characterized by the performance, the functionality, comfort, the fashion and aesthetics. The requirements of the sports activities direct industries towards several optimizations, such as the reduction of friction, the thermoregulation improvement, the mechanical resistance, the safety, and the reduction in perspiration. In the medical environment, a technological development was observed during the ten last years. Based on their barrier effect, at their capacity of absorption, their biocompatibility and their contention capacity, the technical textiles manage to answer multiple features in this sector. For example, the introduction of hydrophilic polymers made it possible to produce perfectly adhesive bandages. The arrival of

certain elastanes and the improvement of a new method of knitting permitted the production of special compression stockings that are pleasant to carry. The development of biocompatible polymeric fibers made possible the use of the textiles in the osteosynthesis prostheses or in vascular surgery. The textile developments today concern not only the imitation of natural fibers, but also the envelopment of new materials that adapt and react to the sensory and body conditions-the clothes we will use in the future will seem like second skin. After breathing fibers, the smart textile fibers adapt to the biological environment of the body. Reference [1] used the microcapsules in the t-shirt and the socks. Several laboratories work on textiles using of the microcapsules containing of the substances with phase shift [2], [3]. The fabrics of Nylon and Lycra, coated with a conducting polymer (polypyrrole) conform to the shape of the human body [4], and function ideally as the biomechanical sensors which can be used in a range of applications to control the human movement. References [5], [6] studied the intrinsic electronic conducting polymers and the installation of the methods of manufacturing of conducting textile fibers. In medicine, 10% of the world technical textile volume are employed for health and can be improved with different technical future textile utilizations [7]. Currently, the smart textiles with integrated sensors are used in the medical field [8]. The new generation of biomedical sensors provides the opportunity for monitoring continually, ambulatory, as well as in residential environments. This generates complete information and allows for improvement of prevention, as well as treatment. Applications of the system "Sensate Liner" are intended for the medical supervision. This program develops and shows useful technologies to apply a systematic approach, making it possible to supervise the medical state of the patients, with a uniform equipped with sensors [8]. Current and future potential applications of three-dimensional polymeric reinforced fabrics manufactured by the processes: weaving, braiding, pricking and knitting, are studied [9]. [10; 11] showed the preliminary results of the application of the textile in the high level sport and medicine. The aim of our study is to show our last textiles development for the high level sport and medicine. The concerns of the present study include swimming, triathlon and skiing

Author: Université de Reims Champagne Ardennes, France.
e-mail: redha.taiar@univ-reims.fr

textiles for sports, and textile used for hemiplegic rehabilitation patients. Different engineering methods were used for the simulation, modelization and optimization fabrics.

II. MATERIAL AND METHODS

a) Fabric

We developed 6 innovative fabric prototypes to answer to the exigencies of the high level athletes in swimming and Triathlon in term of increasing performance and hemiplegic patients in terms of

rehabilitation. The objective is to develop a hydrophobic textile in the aim to decrease the interaction between the drop and the fibers. We opted for the high-tech polyamide fiber and elastanes, in the production of the textile Figure 1. The low density of the fibers makes it possible to produce a very lightweight fabric. The textile absorbs an extremely small amount of moisture, which means that the material cannot become saturated, hence slowing the swimmer down. When wet, polyamide fibers are almost as strong as when they are dry.

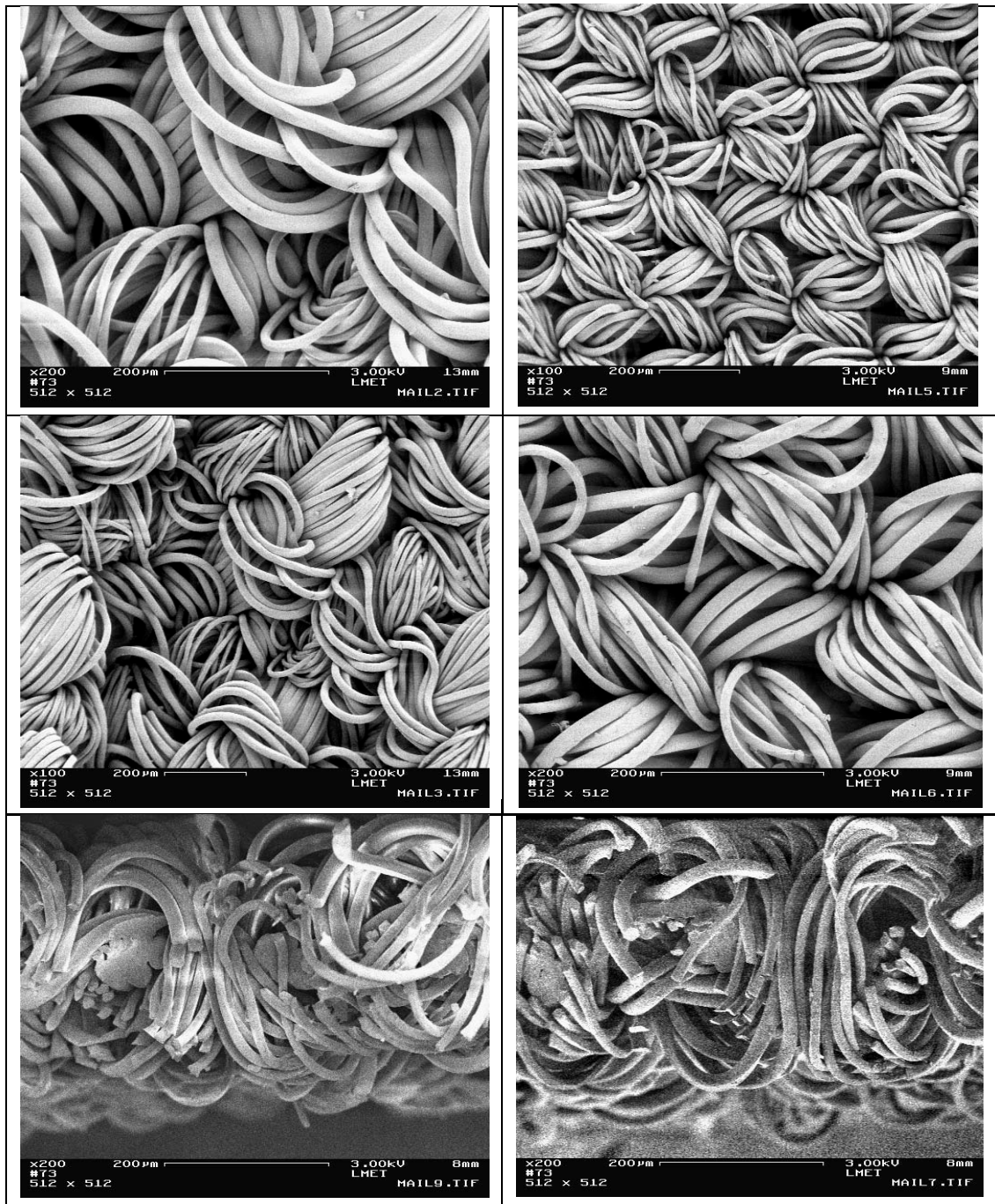


Figure 1 : Scanning Electron Microscopy SEM for the 6 polyamide fibers developed. The pictures obtained are in expansion x 100 and 200

b) In static mode study: Contact angle and disconnecting liquid drop measurements

Static contact angles were measured with a GBX Digidrop apparatus fitted to a tiltable sample carrier supported by an x-y adjustable stage (Figure 2). This sample carrier was capable of a full of 360° rotation. Video cameras with a light source permit the view of the liquid drop. A schematic description of this apparatus is presented in figure below. A finite drop volume of liquid was deposited on the horizontal substrate using a micro syringe. The contact angle is given as a function of time. Contact angle calculation was performed with the GBX scientific instrumentation software. This program allows a 50 image per second's analysis. Image of both side of the drop was captured on a computer. Then the boundary of the drop was analyzed and contact angles

were calculated. An equilibrium contact angle is determined when the drop reaches a metastable equilibrium. All equilibrium contact angles measurements were performed with 5 μ l drops. A minimum of ten measurements are often made and the numbers averaged. A minimum drop volume is predicted for the critical inclined plane conditions. A 15 μ l liquid drop is retained for this experiment, and after drop deposition the plane was slowly tilted. The experimental configuration meant that the camera, light source, and substrate rotated in synchro which made it easier to detect initial drop movement. Just before the drop began to move, the receding contact angle, the advancing contact angle and the critical angle of tilt were recorded. Ten measurements were done for each result.

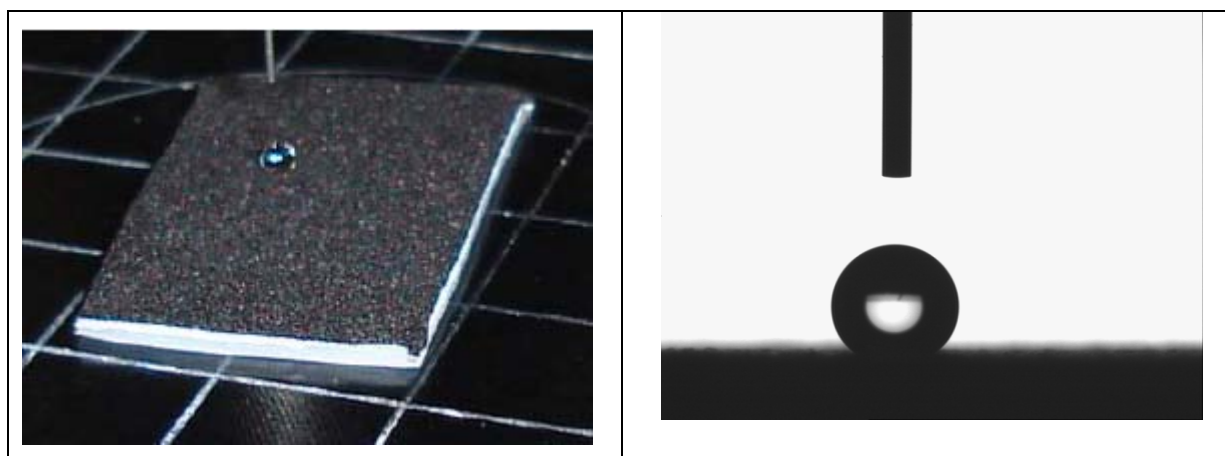


Figure 2 : GBX Digidrop destined for the measure of the contact angle of different material

c) Experience in dynamic mode: method of Wilhelmy

The dynamic advancing and dynamic receding contact angles of water on the swimsuit sample were measured by the Wilhelmy plaque method with K12 Krüss tensiometer. A schematic description of this apparatus is presented in figure below. To begin the measurements, the sample suspended with the bottom edge nearly touching the surface of the liquid. This is the position of the zero force. The sample is lowered until it touches the liquid. This is the zero position. The force on the sample is measured as it is cycled slowly down and up. The depth of immersion of the sample is chosen to 15 mm and the rate of immersion and withdrawal cycles is fixed to 3 mm/min. The waiting time at the returned point is 10 seconds. For a swimsuit sample given, when the immersion and withdrawal cycle is terminated the sample is replaced by another dry sample and the wetting cycle is repeated. Three cycles are repeated in that way. The analysis of these curves allows determining the angles of dynamic impact (angles of

impact forward and backward). In dynamic conditions the name of hysteresis is used. He is defined as the difference between the minimum of the values of contact angle measured, so called receding contact angle (θ_r), and the maximum of the values of contact angle measured, so called advancing contact angle (θ_a). In dynamic, we push the fabric forward we calculate the contact angle and after the same in a backward (Figure 3).

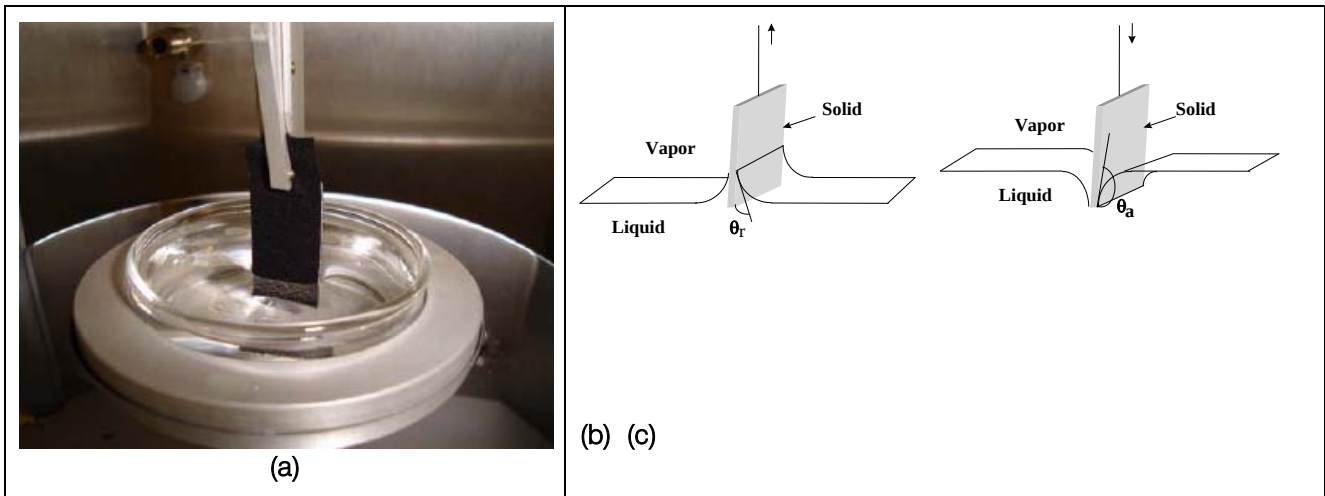


Figure 3 : Illustration of the Wilhelmy plate method in (a), Withdrawal cycle in (b) and Immersion cycle in (c)

III. RESULTS AND DISCUSSION

Different tests were used in the aim to quantify the interaction between the water drop and the fabric. These tests were allowed to study hydrophobicity of the fabric. If the fabric is hydrophobic the materials remain dry and don't get wet. Contrary, if the fabric is hydrophilic the material wet. In this experimentation 6

fabrics have been studied in static (Figure 4) and dynamic conditions (Figure 5). In the figure 4 we can observe the behavior of the drop on the textile. The textile stay hydrophobic in (c) and for another simple (d) the textile absorb the drop and become hydrophilic. In figure 5 the kinetic of the textile behavior during the immersion and immersion phases.

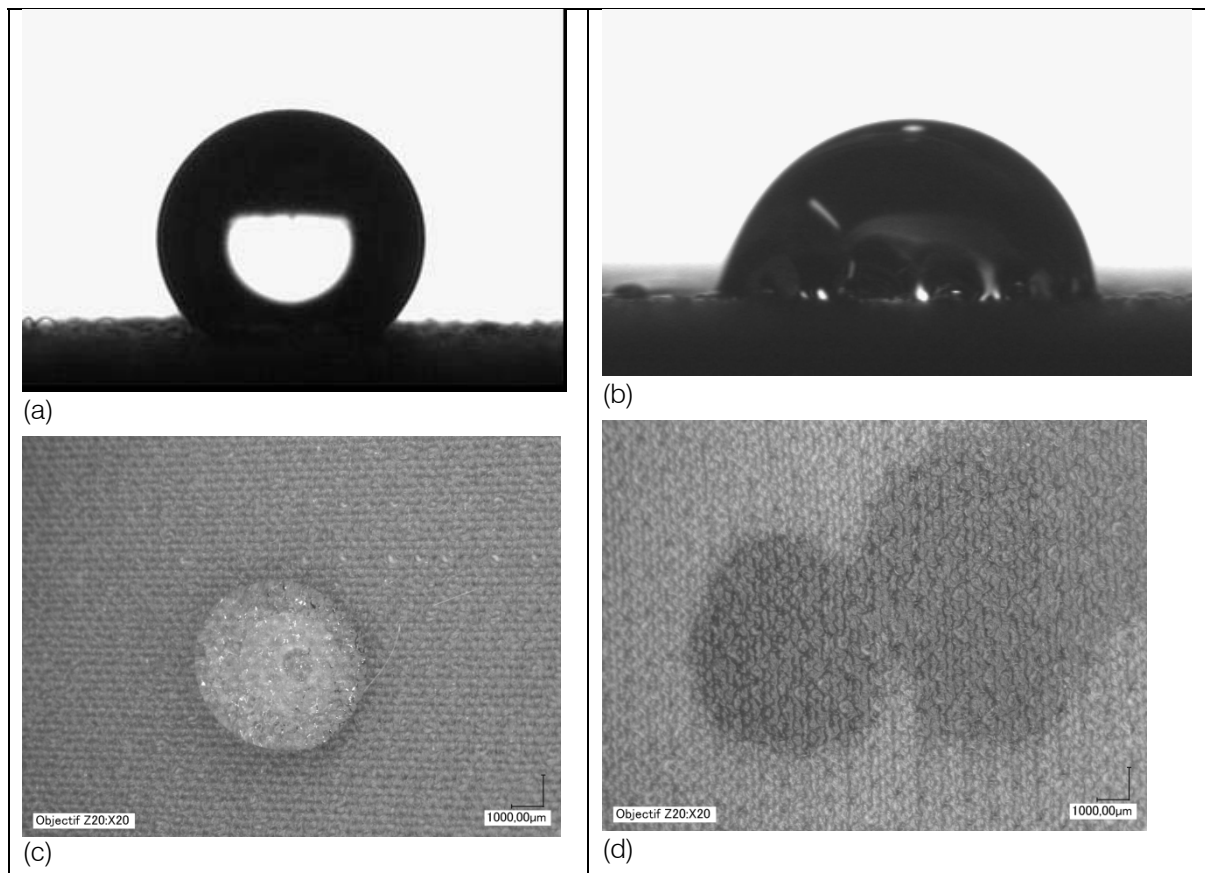


Figure 4 : static drop behavior on the fabric: hydrophobic material in (a) and hydrophilic material in (b). In (c) the behavior of the drop on textile and his absorption in (c)

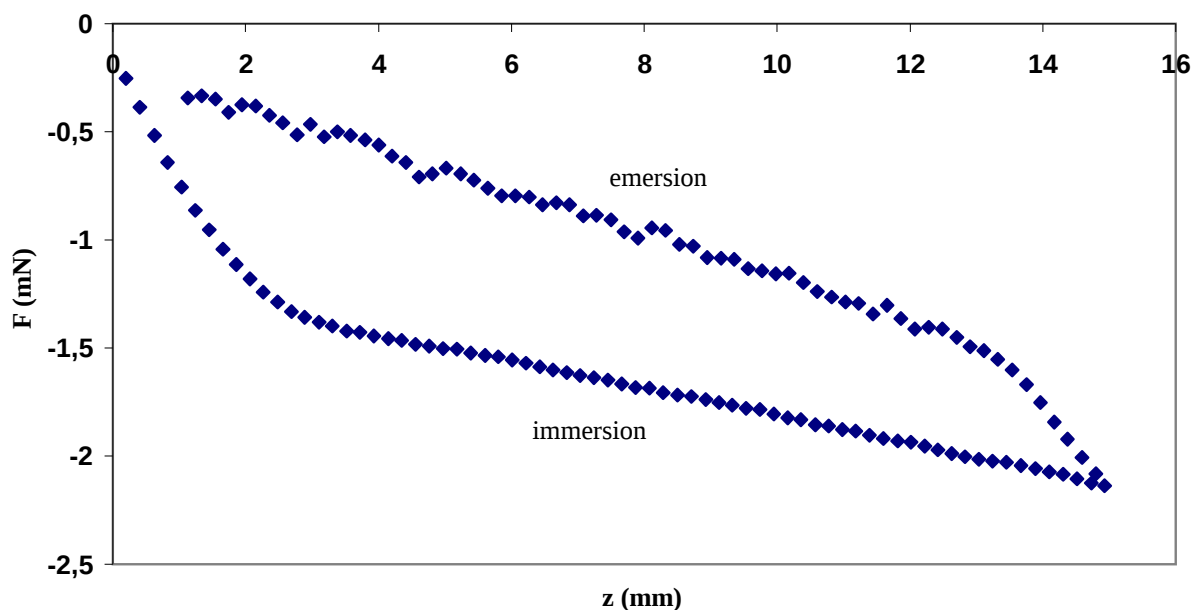


Figure 5 : dynamic drop behavior on the fabric (hysteresis). The material stays hydrophobic during the both phase's emersion and immersion (Wilhelmy plate method)

Our Results showed the hydrophobic characteristics of all the fabrics. In static and dynamic, the angles achieved are close for all the fabrics we studied. They are hydrophobic and stay dry during the experimentation. Like mentioned above the objective

was to develop a hydrophobic textile in the aim to decrease the interaction between the drop and the different fabrics. The Table 1 summarizes the different values of the static and dynamic angles that we obtained.

Table 1 : static and dynamic behaviors of the different textiles

<i>Fabric</i>	θ_E <i>static</i>	θ_A <i>dynamic</i>	θ_R <i>dynamic</i>	$\theta_A - \theta_R$ <i>hystérésis</i>	% diff between static and dynamic teta E and teta A
Textile 1	142°	141°	~ 107°	~ 34°	0,70
Textile 2	140°	136°	~ 117°	~ 19°	2,86
Textile 3	141,5°	132°	~ 109°	~ 23°	6,71
Textile 4	141	139°	~ 90°	~ 49°	1,42
Textile 5	141,5°	132°	~ 108°	~ 24°	6,71
Textile 6	141	133°	~108	~25°	7,13

In the static conditions the angle values are very close numerically to each other (between 140° and 142° in average). The high angle values indicated the hydrophobic characteristics of the different textiles tested. In static the drop maintained its morphology for a long time. The results for the textile behavior stay hydrophobic and remain dry. In dynamic mode, the values for the forward angles are equally close, between 132° and 141°. But, for the backwards contact angle the difference between fabrics is more significant (between 90° and 117°). In dynamic, during the fabric entry into the water the force necessary is more beneficial when the textile is hydrophobic. For the results, the drop doesn't glue to the fabric decreasing, friction and the boundary layer. We noted for both measurements, static and dynamic, that the fabrics stay dry during the experimentations. The hysteresis corresponding to the difference between the forward angle and the backward

angle indicated that the fabrics present hydrophobic behavior. It was weakest for the fabric T2 and strongest for the fabric T4 and can be due to the roughness, or to the heterogeneity of the surface. No significant difference was obtained in comparison of the hysteresis of the fabrics in dynamics and static ($p > 0.05$). In the present study we developed several prototypes which will be intended for high level sport performance like swimming and the triathlon. These innovative processes will be adapted for medical use. The medical example relates the contribution of fabrics in helping hemiplegic patients float on the water's surface. This water rehabilitation will help decrease scabs on hemiplegics by reducing the contact between the body and the wheelchair. The figure 5 showed our first modelization of the wheelchair patient position (a) [12; 13], swimming CAD analysis (b) [14] and skiing in (c).

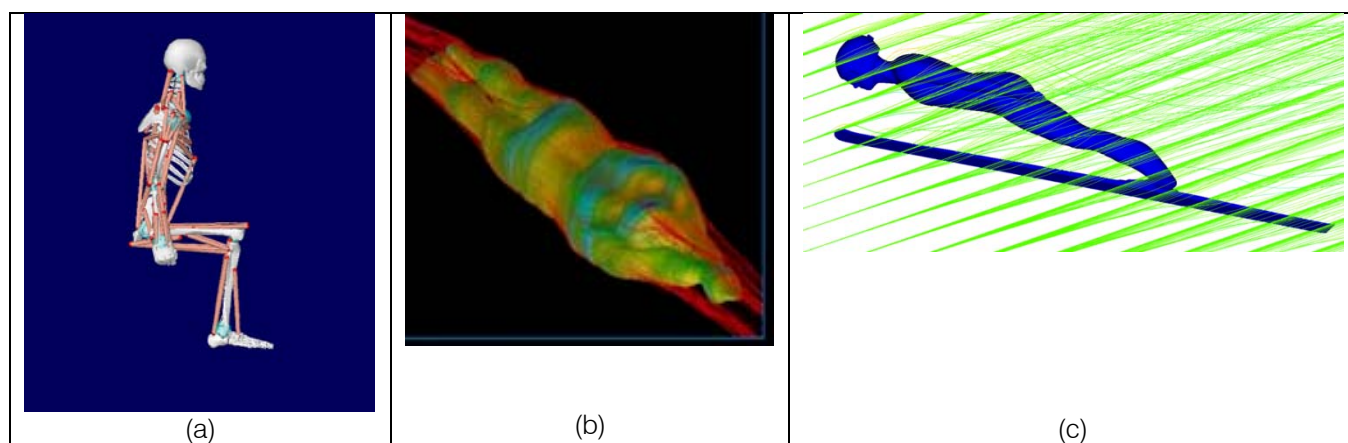


Figure 5 : Modelization and simulation of the body behavior in the different aims of our study: in (a) modelization and simulation of the wheelchair position, in (b) and (c) the swimming and triathlon simulation and skiing in (c)

IV. CONCLUSION

The solutions for medical and sports needs will increasingly take into account mechanical human specifications. In sports, performance improvement in the great events such as the Olympic Games is tributary in part by these textile technologies. They will find their contribution in the amelioration of muscular work, the reduction of hydrodynamical and aerodynamical resistance. In medicine, the advanced textiles will permit the development of assistance solutions tools for patient function, such as passive or active resistance. Our future work will permit to present the results after the experimentation on patients' utilization.

REFERENCES RÉFÉRENCES REFERENCIAS

1. N. Gordon, "Application of microencapsulation in textiles" *Journal International of Pharmaceutics* vol 242, 2002, pp.55–62.
2. N. Sarier, E. Onder, "The manufacture of microencapsulated phase change materials suitable for the design of thermally enhanced fabrics" *Thermochimica Acta*, vol. 452, Issue 2 , 2007, pp.149–160.
3. B. Ying, Y. Kwok, Y. Li, Q. Zhu, C. Yeung, "Assessing the performance of textiles incorporating phase change materials" *Polymer Testing* vol23 , 2004, pp.541–549.
4. J. Wu, D. Zhou, C.O. Too, G.G. Wallace, "Conducting polymer coated lycra" *Synthetic Metals* vol155, 2005, pp.698–701.
5. B. Kim, V. Koncar, C. Dufour, "Polyaniline-Coated PET Conductive Yarns: Study of Electrical, Mechanical, and Electro-Mechanical Properties" *Journal of Applied Polymer Science* vol 101, Issue 3, 2006, pp.1252–1256.
6. B. Kim, V. Koncar, E. Devaux, C. Dufour, P. Viallier, "Electrical and morphological properties of PP and PET conductive polymer fibers" *Synthetic Metals* vol146, 2004, pp.167–174.
7. D. De Rossi, F. Carpi, F. Lorussi, A. Mazzoldi, R. Paradiso, E. P. Scilingo, A. Tognetti, "Electroactive fabrics and wearable biomonitors devices", *AUTEX Research Journal*, vol 3, n°4, 2003, pp 180–185.
8. M. Engin, A. Demirel , E. Z. Engin , M. Fedakar, "Recent developments and trends in biomedical sensors" *Measurement* vol37, 2005, pp.173–188.
9. A.P. Mouritz, M.K. Bannister, P.J. Falzon, K. H. Leong, "Review of applications for advanced three-dimensional fibre textile composites" *Composites* vol 30, Issue 12, 1999, pp.1445–1461.
10. Taiar R. Textile Technology: Application in Sport and Medicine (2014), *International Journal of Chemical, Nuclear, Metallurgical and Materials Engineering* 08(09):760–763.
11. R. Taiar, F.C. Boyer, N. Roche, D. Pradon, (2013). Technical and smart fabrics fibers orthosis for recurvatum knee in hemiplegic patients. *Annals of Physical and Rehabilitation Medicine*, Volume 56, Supplement 1, Pages e25–e26
12. Y. Traore, P. Lestriez, R. Taiar, K. Debray, D. Pradon, F. Boyer (2013). Design and optimization of a new kind of manual wheelchair. *Annals of Physical and Rehabilitation Medicine*, Volume 56, Supplement 1, Page e26.
13. Taiar, R, Y. Toshev, F. Boyer, A. Cherouat, G. Agnesina, S. Milusheva (2007). CAD and mechanical development of a new kind of hemiplegics orthosis. *Journal of series on Biomechanics*, Vol.23, N° 1 page 35–42.
14. H. Zaidi, R. Taiar, S. Fohanno, G. Polidori (2010). Turbulence model choice for the calculation of drag forces when using the CFD method, *Journal of Biomechanics*, Volume 43, Issue 3, 10 February 2010, Pages 405–411.