

Description

[0001] **Title of Invention : [0001] MULTILAYER MATERIAL FOR THE CREATION OF A MULTISPECTRAL (VIS-NIR-TIR) INDIVIDUAL CAMOUFLAGE**

[0002] MULTILAYER MATERIAL FOR THE CREATION OF A MULTISPECTRAL (VIS-NIR-TIR) INDIVIDUAL CAMOUFLAGE

Technical Field

[0003] The present invention relates to a multilayer material for the creation of a multispectral individual camouflage, particularly in the wavelengths of the visible spectrum (VIS), near-infrared (NIR), and thermal emissions (TIR).

Background Art

[0004] The topic of camouflage has always been of interest for specific activities in the military and defense sectors. The ability to combine camouflage capabilities across different wave spectra (VIS – NIR - TIR) into a single article is advantageous in terms of survival and operational effectiveness, as well as logistical aspects such as transportability, adaptability, and ease of wear.

[0005] CN 111844997 A and RU2558347 C2 describe materials that incorporate insulating layers made from polyethylene films to suppress thermal infrared radiation. CN 115679710 A discloses a combination of nitrile rubber, ethylene propylene diene monomer (EPDM), and acrylic resin for similar purposes. LV 15375 B and US 8077071 B2 report the use of internal layers made from aerogel and/or non-woven fiberglass to achieve stable thermal insulation. US 2019/0017785 A1 describes a polyurethane layer that incorporates glass microbubbles, the polyurethane layer being perforated to provide ventilation and reduce heat buildup. DE 102006005662 A1 describes a material that combines air spaces with a polyurethane foam layer and a self-foaming PVC coating to maximize insulation. Despite the use of insulating layers that could seem reasonable, pursuing insulation to achieve thermal camouflage has the main limitation of causing overheating to the user. It can cause overheating for the user causing discomfort, excessive fluid loss, exacerbating stress and physical exertion. In addition, insulating materials tend to lead to thermal losses over time because of “thermal overload” which eventually causes thermal camouflage failure.

[0006] CN203869593U and DK2449334T3 propose visual camouflage prints on metallized fabrics by using specific infrared-emissive inks. The aforementioned US 2019/0017785 A1 also describes camouflage materials that utilize metallic coatings to enhance visual and infrared concealment. However, prints on metallized fabrics tend to fade over time and with exposure to water, reducing their effectiveness, longevity, and reliability in the field. What is more, printed inks on metalized fabric result in high

shiny appearance, looking bright in the VIS spectrum particularly at daylight or when irradiated by lasers and VIS and NIR illuminators.

[0007] The use of nanoparticles is significant in multispectral camouflage technologies. Various inventions describe materials employing a range of metals, minerals, and polymers in nanoparticle form. For example, CN115679710A claims to achieve thermal and radar camouflage through conductive carbon black nanoparticles and nickel-plated carbon nanotubes. Similarly, the previously mentioned US 2019/0017785 A1 describes a camouflage material using microbubbles and metallic coatings to enhance radar dispersion. US 10960654 B2 mentions the use of glass microbubbles to scatter and obscure infrared and microwave radiation. Additionally, other documents such as RO135730A2, US11566370, US8077071B2 describe how metallic nanoparticles combined with binders, solvents, and polymers can be used to achieve thermal infrared reflection and thus obtain thermal camouflage clothing. Although nanoparticles offer advanced camouflage capabilities, their production is often costly, involving numerous processes that are not easily scalable at an industrial level. Furthermore, the thermal effectiveness of such garments tends to degrade over time and with air and water exposure, making this type of clothing inconsistent in terms of thermal camouflage performance. This is due to nanoparticles being prone to release through abrasion and other mechanical stresses, sweat, irradiation, washing, and temperature changes. This not only raises concerns regarding the reliability and longevity of camouflage but also highlights the more relevant issue of nanoparticle release and its toxic effects on human health, most of which remain unknown.

[0008] See also L Almeida and D Ramos 2017 Health and safety concerns of textiles with nanomaterials *IOP Conf. Ser.: Mater. Sci. Eng.* 254 102002 - DOI 10.1088/1757-899X/254/10/102002; Periyasamy AP. Microfiber Emissions from Functionalized Textiles: Potential Threat for Human Health and Environmental Risks. *Toxics*. 2023 Apr 24;11(5):406. doi: 10.3390/toxics11050406. PMID: 37235219; PMCID: PMC10221355.; Som C, Wick P, Krug H, Nowack B. Environmental and health effects of nanomaterials in nanotextiles and façade coatings. *Environ Int.* 2011 Aug;37(6):1131-42. doi: 10.1016/j.envint.2011.02.013. Epub 2011 Mar 11. PMID: 21397331.; Najahi-Missaoui W, Arnold RD, Cummings BS. Safe Nanoparticles: Are We There Yet? *Int J Mol Sci.* 2020 Dec 31;22(1):385. doi: 10.3390/ijms22010385. PMID: 33396561; PMCID: PMC7794803.; Saleem H, Zaidi SJ. Sustainable Use of Nanomaterials in Textiles and Their Environmental Impact. *Materials (Basel)*. 2020 Nov 13;13(22):5134. doi: 10.3390/ma13225134. PMID: 33203051; PMCID: PMC7696606.

[0009] In conclusion, current techniques for individual multispectral camouflage have a range of approaches, each with certain limitations.

Summary of Invention

- [0010] The present invention aims to provide a multilayer material for the creation of a multispectral individual camouflage that is reliable, efficient, safe, and high scalable.
- [0011] According to the invention, a multilayer material is provided for the realization of a multispectral (VIS-NIR-TIR) individual camouflage, comprising:
- [0012] a sheer/semi-sheer layer (4) with a light transmission level between 20% and 80% equivalent to 80 and 15 deniers, printed with camouflage colors for VIS and NIR with low NIR reflectance (NIR 20% - 40%); and a coated layer, including the following metals:
- [0013] Copper between 10% and 35%
- [0014] Nickel between 2% and 10%
- [0015] Aluminum between 5% and 15%
- [0016] Silver between 5% and 40%
- [0017] Titanium between 5% and 25%
- [0018] In particular, the material according to the present invention can be used to create a multispectral (VIS-NIR-TIR) individual camouflage comprising a leg cover, a poncho, an arm cover, a hood, a face/weapon cover. Moreover, a bolero design with a hood and arm cover can be produced. In the same way, this material can be utilized to produce Ghillie suits and various types of suits and camouflage for weapons, optics, binoculars, and targeting systems.
- [0019] The camouflage according to the invention offers a high degree of concealment both during the day and at night, in manifold environments and circumstances. This provides significant logistical advantages in terms of transportability, versatility, and adaptability. These factors are particularly relevant in tactical-operational settings, as having a single garment—albeit composed of modular and integrable sections—enhances operational capabilities, ensuring camouflage functions in both daytime and nighttime contexts.
- [0020] Therefore, the individual camouflage garment is modular and multifunctional, integrating camouflage capabilities across the specified wavelength ranges into a single multilayered outfit. This outfit is obtained by various items, is lightweight, breathable, flexible, adequately silent during movement, and easy to wear over any other clothing and/or equipment.
- [0021] The camouflage according to the invention aims to provide comprehensive protection across the visible spectrum (VIS), near-infrared spectrum (NIR), and thermal spectrum (MWIR – LWIR). Therefore, the camouflage is based on the use of a multilayer material that allows the wearer to use it for both static observation activities and

dynamic reconnaissance actions while being simultaneously protected across the VIS the whole TIR spectrum.

- [0022] The multilayer material according to the invention does not rely on thermal insulation; it is breathable and lightweight, making it suitable for amphibious operations. Its multispectral properties do not degrade over time or with exposure to water. Furthermore, these properties are exhibited on the same side of the fabric without needing to flip it for daytime or nighttime camouflage. Additionally, the multilayer material quickly adapts to temperature changes and returns to ambient temperature in half the exposure time compared to known materials when exposed to direct heat sources, such as sunlight. Importantly, the garment made from this multilayer material does not expose the user to potential nanoparticle release and their associated toxicity.
- [0023] The camouflage garment according to the invention features relatively low production costs and is easily scalable at an industrial level.
- [0024] The camouflage according to the invention is designed specifically to maximize the concealment of the human silhouette and enhance ergonomics.
- [0025] The main individual camouflage garment consists of six integrable components: a multifunctional poncho with a removable hood, a face/weapon cover, forearm and hand coverings, leg coverings, and a bolero with a hood that includes hand coverings. This modularity allows for adaptation to various activities and environmental conditions without the need for external logistical support or interrupting operational continuity. The multifunctional poncho can be replaced by a jacket with removable back and front sections. Furthermore, on all these items a paracord grid can be sewn as to allow application of 3D elements and/or natural elements on the field.

Brief Description of Drawings

- [0026] The present invention will be described with reference to the attached figures, where:
- [0027] [Fig.1] [Fig.1] is a schematic section of a first embodiment of the multilayer material according to the invention in summer version;
- [0028] [Fig.2] [Fig.2] is a schematic section of a second embodiment of the multilayer material according to the invention in summer version;
- [0029] [Fig.3] [Fig.3] is a schematic section of a third embodiment of the multilayer material according to the invention in winter version;
- [0030] [Fig.4] [Fig.4] is a front schematic view of a complete general configuration of a camouflage made with the multilayer material according to the invention, consisting of leg covering, poncho, arm covering, hood, and face/weapon covering;
- [0031] [Fig.5] [Fig.5] is a rear schematic view of the configuration shown in [Fig.4];

- [0032] [Fig.6] [Fig.6] is a front schematic view of the camouflage garment according to the invention featuring only the poncho;
- [0033] [Fig.7] [Fig.7] is a three-quarter schematic view of the camouflage garment according to the invention with leg covering, arm covering, and face/weapon covering;
- [0034] [Fig.8] [Fig.8] is a front schematic view of the camouflage garment according to the invention with a bolero that replaces the hood and face/weapon covering from [Fig.4];
- [0035] [Fig.9] [Fig.9] is a three-quarter schematic view of [Fig.8];
- [0036] [Fig.10] [Fig.10] represents the camouflage pattern scheme for VIS and NIR printing.

Description of Embodiments

- [0037] Figures 1 to 3 illustrate three embodiments of the multilayer material for a camouflage according to the invention. All three embodiments share a sheer/semi-sheer layer 4 and a coated layer 5.
- [0038] The sheer/semi-sheer layer can be made from fabrics selected from polyester, polyamide, viscose, cotton, and nylon. This layer has a weight ranging from 40 g/m² to 80 g/m² with a light transmission level between 20% and 80%, equivalent to 80 and 15 deniers and is printed with VIS camouflage colors that exhibit low near infrared reflectance (NIR) of 20% - 40%.
- [0039] The coated layer 5 can be made from fabrics chosen from polyester and nylon, preferably coated through electroless metal plating or physical vapor deposition (PVD), a technology used for depositing thin metallic films on substrates. This process occurs in vacuum chambers where the metals intended for deposition are evaporated. The metals used include:
- [0040] Copper: 10% - 35%
- [0041] Nickel: 2% - 10%
- [0042] Aluminum: 5% - 15%
- [0043] Silver: 5% - 40%
- [0044] Titanium: 5% - 25%
- [0045] With reference to [Fig.1], the first embodiment for a summer camouflage includes, opposite the sheer/semi-sheer layer 4, an opaque layer 6 weighing between 80 g/m² and 120 g/m², printed with camouflage colors exhibiting low infrared reflectance (NIR) of 20%-40%. This opaque layer is made from fabrics selected from polyester, viscose, cotton, nylon and polyamide depending on the operational uses.
- [0046] Both the sheer/semi-sheer layer 4 and the opaque layer 6 may have different camouflage patterns depending on the environment of use or may feature a single color if not required otherwise. The sheer/semi-sheer layer 4 can present digitally printed pigments that represent a 2D camouflage pattern, effective in the VIS and

NIR spectra. This outermost layer is printed with VIS-NIR inks, achieving an NIR reflectance of 30% - 40%, depending on the usage environment, making it visible in the VIS and NIR spectra but almost transparent in the TIR spectrum. The coated layer 5, made of polyester or nylon, serves as an intermediate layer weighing between 60 g/m² and 100 g/m², is breathable, and acts as a substrate for electromagnetic shielding by dispersing and reflecting thermal infrared radiation. The coated layer 5 can have a metal combination as above said. Silver is preferred in the coated layer due to its superior thermal conductivity compared to other metals and its high shielding effect. The combination of the sheer/semi-sheer layer 4 and the coated layer 5 provides lightweight camouflage that offers simultaneous VIS – NIR and TIR concealment. The sheer/semi-sheer layer 4 provides VIS and NIR concealment while being semi-transparent in the TIR spectrum. Indeed, in terms of thermal concealment, the coated layer offers electromagnetic interruption and thermal reflection, emulating average ambient temperature. This combination of the sheer/semi-sheer layer 4 and of the coated layer 5 is breathable, does not isolate the user since both layers are lightweight and highly breathable, and maintains stability over time and with water exposure, ensuring durability and reliability.

[0047] The opaque layer 6 is heavier than both the sheer/semi-sheer layer 4 and coated layer 5, weighing between 80 g/m² and 120 g/m². The sheer/semi-sheer layer 4 and opaque layer 6, differing in weight, cover both sides of the coated layer 5, enclosing it within. Both layers exhibit similar responses in the VIS and NIR spectra; however, the sheer/semi-sheer layer 4 is almost completely transparent in the TIR spectrum allowing substantial thermal radiation reflection through the coated fabric 5. This results in adequate TIR concealment with the surrounding environment. Both sides of the multispectral camouflage made using this first embodiment provide multispectral concealment (VIS – NIR – TIR), but the opaque side 6 is more suitable for daytime use or when high thermal reflection is not necessary, such as in warm climates. Conversely, the sheer/semi-sheer side 4 is more appropriate for nighttime use or when high thermal reflection is needed, such as in cold climates.

[0048] The second embodiment of multilayer material according to the present invention ([Fig.2]) for a summer camouflage comprises a second sheer/semi-sheer layer 4 adjacent to the coated layer 5, opposite to the first sheer/semi-sheer layer.

[0049] The third embodiment of multilayer material according to the present invention ([Fig.3]) for a winter camouflage includes, opposite to the first sheer/semi-sheer layer 4, adjacent to the coated layer 5, in succession:

[0050] a fabric spacer layer 7, made of carbon fiber fabric layer or a 3D spacer fabric, weighing between 100 g/m² and 250 g/m²;

[0051] a second coated layer 5;

- [0052] an opaque layer 6.
- [0053] The addition of carbon fiber fabric layer 7 provides enhanced shielding capabilities. This embodiment offers greater scattering of electromagnetic radiation by approximately 15%, making it more suitable for winter conditions where there is a significant temperature difference between the environment and human body.
- [0054] Totally the multilayer material according to the present invention has a thickness ranging from 0.1 mm to 0.5 mm, with a weight between 120 g/m² and 600 g/m².
- [0055] A key feature of the design and interaction of these fabrics is their rapid thermal response. The metallic fabric quickly dissipates thermal infrared radiation TIR, while the polyester/viscose/polyamide/cotton/ nylon fabrics, due to their lightweight and "detached" positioning from the internal metallic fabric, minimally retain TIR radiation. This configuration allows for quick adaptation to environmental temperature changes.
- [0056] The outer layers are treated with printing coloration using industrial machines for printing fabrics with the addition of "carbon black" for low NIR reflectance, (or digital printing of pigments) reproducing different camouflage patterns depending on the environment of use. The weight of each fabric layer in the multilayer material ranges from 40 g/m² to 120 g/m², except for the additional winter fabric made of 100% carbon fiber (or 3D spacer fabric), which weighs between 100 g/m² and 250 g/m². The coupling of the fabrics is achieved through double or triple machine stitching with nylon, cotton, polyester or mixed threads. The overall thickness of the fabric thus created, when pressed, is approximately 0.1 – 0.5 mm. However, the fabrics are sewn together respecting an overlap of about 1.5 cm on each edge to allow for a variable air cushion that contributes to thermal camouflage capability.
- [0057] The outer layers made of polyester, cotton, viscose, polyamide or nylon can be treated in various ways to enhance or add multispectral properties to the fabric and clothing. For example, the reflectance of thermal radiation from the fabric can be increased by adding silver micro and nanoparticles using propanol and chitosan (or PVA) as a binder through spraying or immersion, as described in literature (*Ribeiro AI, Shvalya V, Cvelbar U, Silva R, Marques-Oliveira R, Remião F, Felgueiras HP, Padrão J, Zille A. Stabilization of Silver Nanoparticles on Polyester Fabric Using Organo-Matrices for Controlled Antimicrobial Performance. Polymers (Basel). 2022 Mar 12;14(6):1138. doi: 10.3390/polym14061138. PMID: 35335469; PMCID: PMC8950105.; Velgosova O, Mačák L, Múdra E, Vojtko M, Lisnichuk M. Preparation, Structure, and Properties of PVA-AgNPs Nanocomposites. Polymers (Basel). 2023 Jan 10;15(2):379. doi: 10.3390/polym15020379. PMID: 36679259; PMCID: PMC9860772.*). Similarly, the outer layer can also be treated with various types of 2D Ti₃C₂T_x MXenes with a lateral flake thickness around 200nm in 5-6

layers of 1 nanometer thickness, to further enhance electromagnetic shielding and absorption properties, as described in Uzun et al. 2021 (Uzun, S., Han, M., Strobel, C. J., Hantanasirisakul, K., Goad, A., Dion, G., & Gogotsi, Y. (2021). *Highly conductive and scalable Ti₃C₂T-coated fabrics for efficient electromagnetic interference shielding*. *Chemical Engineering Journal*, 404, 126703. <https://doi.org/10.1016/j.cej.2020.126>) and others (Y. Li, C. Xiong, H. Huang, X. Peng, D. Mei, M. Li, G. Liu, M. Wu, T. Zhao, B. Huang, *2D Ti₃C₂T_x MXenes: Visible Black but Infrared White Materials*. *Adv. Mater.* 2021, 33, 2103054. <https://doi.org/10.1002/adma.202103054> ; Meikang Han, Christopher Eugene Shuck, Roman Rakhmanov, David Parchment, Babak Anasori, Chong Min Koo, Gary Friedman, and Yury Gogotsi. *ACS Nano* 2020 14 (4), 5008-5016 DOI: 10.1021/acsnano.0c01312). However, processing MXenes is slow and requires appropriate timing to avoid oxidation during various immersion processes. Similarly, radar camouflage can be improved by adding radar-absorbing materials; for example, carbon nanotubes with an average diameter between 60nm and 80nm and graphene flakes with an average diameter between 2 micrometers and 3 micrometers can be added through immersion and thermal fixation as described in literature (S.-H. Kim, S.-Y. Lee, Y. Zhang, S.-J. Park, J. Gu, *Carbon-Based Radar Absorbing Materials toward Stealth Technologies*. *Adv. Sci.* 2023, 10, 2303104. <https://doi.org/10.1002/advs.202303104> ; Gu W, Shi J, Zhang J, Jia Q, Liu C, Ge H, Sun Q, Zhu L. *Fabrication and Investigation of the Microwave Absorption of Nonwovens Modified by Carbon Nanotubes and Graphene Flakes*. *Molecules*. 2023 Sep 3;28(17):6419. doi: 10.3390/molecules28176419.PMID:37687248; PMCID: PMC10490006.; S.-H.Kim,S.-Y.Lee,Y.Zhang,S.-J.Park,J.Gu ,*Carbon-Based Radar Absorbing Materials toward Stealth Technologies*.*Adv.Sci.* .2023 ,10 ,2303104 . <https://doi.org/10.1002/advs.202303104>).

- [0058] For arctic environments aiming to adapt UV reflectance to snow and ice conditions similar treatments can be performed on the outer layer by adding Titanium and/or Zinc to the fabric following procedures widely described in literature (Ortelli S., Costa AL., Dondi M.. *TiO₂ Nanosols Applied Directly on Textiles Using Different Purification Treatments*.*Materials (Basel)*. 2015 Nov24;8(11):7988-7996. doi:10.3390/ma8115437.PMID:28793692;PMCID:PMC5458890.; Rashid, M.M.,Simončič,B.,&Tomšič,B.(2021).Recent advances in TiO₂-functionalized textile surfaces. *Surfaces and Interfaces* ,22 ,100890 . <https://doi.org/10.1016/j.surfin.2020.100890>; Tania IS, Ali M. *Coating of ZnO Nanoparticle on Cotton Fabric to Create a Functional Textile with Enhanced Mechanical Properties*. *Polymers (Basel)*. 2021 Aug13;13(16):2701.doi:10.3390/polym13162701.PMID:34451240; PMCID:PMC8400654.).

- [0059] Finally, hyperspectral camouflage can be achieved by adding clays such as Palygorskite to the fabric as a standalone treatment or alongside the aforementioned processes. See *Lu, H., Bai, X., Wang, Z., Guo, Y., Zhang, L., Weng, X., Xie, J., Liang, D., & Deng, L. (2023) Hyperspectral camouflage coating using Palygorskite to simulate water absorption of healthy green leaves. Materials Science in Semiconductor Processing ,156 ,107293 . <https://doi.org/10.1016/j.mssp.2022.107293>; D.Xie, M.Zu, M.Li, D.Liu, Z.Wang, Q.Li, H.Cheng, A Hyperspectral Camouflage Colorant Inspired by Natural Leaves. Adv.Mater .2023 ,35 ,2302973. <https://doi.org/10.1002/adma.202302973>).*
- [0060] This type of treatment provides a match with the signature of green leaves across the electromagnetic spectrum.
- [0061] Overall, this multilayer material according to the present invention allows for the creation of a modular and multifunctional individual garment that integrates camouflage capabilities across the specified wavelength ranges into a single multilayered outfit. This outfit is composed of various components, is lightweight and breathable, flexible, adequately silent in movement, and easy to wear over any other clothing or equipment. Such garments are specifically suited for military-tactical use in reconnaissance and observation activities. Additionally, this fabric composition features inherent water-repellent characteristics due to the nature of some of the fabrics used, ensuring breathability that is enhanced by both the non-adherent coupling process of the fabrics and the unique design of the multispectral camouflage garment. This individual garment can thus be utilized in any weather conditions and environment, and it can be further enhanced with fire-retardant treatments and/or additional chemical treatments for multispectral camouflage. The tensile strength and tear resistance of the multilayer material are ensured by the coupling system of the fabrics without adhesives and by the redundancy of stitching between various sections of the camouflage garment. Through experimentation and research, optimal combinations have been achieved for creating an efficient, lightweight modular garment designed specifically to "break up" typical human shapes, providing camouflage in both the visible (VIS) spectrum and infrared (NIR – TIR) spectrum. The multilayer material is pre-cut according to different designs depending on the parts of the camouflage garment to be made. Essentially, individual pre-formed sections are created for ponchos, hoods, hand covering, leg covering, face/weapon coverings, and boleros with hoods, as will be detailed later. The components ensure camouflage in the visible spectrum due to the camouflage patterns of the outer fabric and the form factor of the head-shoulder area of the garments, as well as camouflage in the NIR and TIR spectra due to the layered composition of the fabric. On the individual garment components, buttonholes made from paracord are fixed using double or triple

machine stitching for oval wooden or plastic buttons with holes that are secured in corresponding positions by passing paracord through the button holes and sewing it with double or triple stitching. The cuts of multilayer material for making various sectors of the individual camouflage garment are sized to allow easy dressing even with typical tactical gear (load-bearing equipment, ballistic plates, various equipment).

- [0062] Referring to [Fig.4], which is a front schematic view of a complete general configuration of a camouflage garment made with the multilayer material according to this invention consisting of leg covering, a poncho, arm covering, a hood, and a face/weapon covering. [Fig.5] is a rear schematic view of the configuration shown in [Fig.4], while [Fig.6] is a front schematic view of the camouflage garment according to the invention featuring only the poncho. The poncho, indicated as 9, is the central piece of the camouflage outfit and can also be used as a camouflaged covering for observation posts. The arm covering 10, leg covering 8, and hood 11 integrate with the poncho. An alternative to hood 11 is bolero 19, which provides better mobility during reconnaissance activities.
- [0063] In this regard, refer to [Fig.8], which is a front schematic view of the camouflage garment according to this invention featuring a bolero with a hood, and [Fig.9], which is a three-quarter schematic view of [Fig.8]. In any case, hood 11 can also be added over bolero 19 or used to camouflage weapons or observation systems such as portable cooled thermal cameras. The hood 11 is designed not to follow human shape and is sufficiently spacious to be worn with helmets equipped with night vision systems while also providing a form factor that disguises typical human silhouette characteristics. In this regard, compare Figures 4 and 5 with [Fig.6].
- [0064] With reference to [Fig.9], at the upper front part of hood 11 is inserted a wire (for example) with a diameter of 0.9 mm, sewn into a reinforced fabric cuff to ensure both support and visibility during activities while also concealing the face when necessary. Also the zipper 22 allows to close the hood. In addition to hood 11, face/weapon covering 12 can be worn to further shield the face and weapon during aiming positions. The bolero 19 with hood is made using the same principle as hood 11 and includes arm covering 10 that also provide hand coveringage.
- [0065] The multispectral camouflage garment constructed as described possesses the following features:
- [0066] Lightweight: Weighing approximately 1,500 g – 2,500 g, complete with a hood.
- [0067] High portability: It can be folded and stored in a bag measuring 40x30x30 cm.
- [0068] Ease of wear: Allows for adjustment and removal without external assistance from the operator.
- [0069] Breathability: Ensures comfort during use.

- [0070] Low absorption of non-persistent rainwater: Facilitates quick drying and is suitable for amphibious use.
- [0071] Tensile strength: Designed for typical tactical use in observation positions.
- [0072] Intrinsic hypoallergenicity: Due to the use of 100% polyester/viscose fabric.
- [0073] User safety: Does not expose the user to nanoparticle release.
- [0074] Ease of movement on the ground: Allows for agile maneuvering.
- [0075] High camouflage capability in the visible spectrum: Achieved through 2D patterns.
- [0076] Strong concealment in the near-infrared spectrum.
- [0077] Thermal camouflage capability: Effective for both winter and summer temperatures.
- [0078] Performance maintenance: Retains effectiveness over long periods of use
- [0079] The specific details of using the multilayer material according to the invention are illustrated with the help of Figures 4 to 9. Figures 4 and 5 show the multispectral camouflage garment (VIS-NIR-TIR) in a complete configuration, excluding bolero 19 with a hood. The simplicity of the design and total body coveringage can be appreciated, starting from leg covering 8, the ample dimensions of poncho 9 allowing for wearing vests, protective gear, and backpacks underneath, and the presence of arm covering 10 that shield hands and forearms. The generous shape of hood 11 breaks up the classic human silhouette with the head standing out from the horizontal shoulder line, allowing easy wearing of helmets and night vision systems. The dimensions of the hood are approximately 130 cm x 50 cm. The hood can be lowered to overlap with face/weapon covering 12. The hood features wooden or plastic oval buttons (“tactical toggles”) 14 secured with paracord and positioned corresponding to paracord buttonholes sewn onto poncho 14. Proper positioning and stability of the hood are also ensured by a wire with a diameter of approximately 0.9 mm inserted into a specially sewn cuff at the upper front. The face/weapon covering 12 is sized to covering even a long weapon in aiming position. The leg covering 8 have suitable width and length to ensure proper movement in tactical posture. All components of the multispectral camouflage garment (VIS-NIR-TIR) are made from multilayer fabric according to the forms of multilayer material described.
- [0080] [Fig.6] shows the camouflage garment in its basic configuration with only poncho 9, made from multilayer material measuring approximately 210 cm x 145 cm. For wearing, an opening is created in a median position, closable with a zipper 13, allowing the poncho to serve as a uniform protective covering for specific static observation posts. On the edges of poncho 9, symmetrical buttonholes made from paracord are sewn on the front, while wooden or plastic oval buttons (“tactical toggles”) are sewn on the back for securing both edges once worn. Similar buttonholes are created on the chest and back for attaching hood 11 using buttons (“tactical toggles”) sewn onto it.

- [0081] [Fig.7] presents a three-quarter schematic view of the camouflage garment according to this invention with leg covering 8, arm covering 10, and face/weapon covering 12. The leg coverings are tubular in shape made from multilayer material according to this invention, measuring approximately 95 cm x 75 cm. Fit and retention in position are ensured by a zipper sewn from the base for about 40 cm, allowing wearing even with boots or climbing gear such as crampons or skis. At the top, an opening allows for easy dressing; an elastic cord of approximately 3 mm is attached to the belt or belt loops of trousers. The arm covering are also made from multilayer material according to this invention in a conical tubular shape flaring towards the forearm, measuring approximately 50 cm x 60 cm. The glove shape at hand is open on the inside, and positioning is secured by fabric sections connecting the edges along with elastic cord, allowing individual finger use similar to snow mittens covering the metacarpus and back of fingers. The face/weapon covering is made from multilayer material according to this invention measuring approximately 60 cm x 35 cm, featuring an elastic cord sewn into a cuff on its shorter side for wearing on the forehead with cord fitting behind the head/helmet. The length of face/weapon covering can be adjusted based on weapon type. [Fig.8] highlights bolero 19 with a hood used as an upper covering system for the multispectral camouflage garment alongside poncho 9. The arm covering, open on their inner side, also covering hands. Bolero dimensions are trapezoidal at approximately 245 cm x 70 cm.
- [0082] The bolero is assembled by attaching extensions for sleeves and an additional extension for the back to its base section, all machine-sewn as previously described. For proper positioning, nylon straps are sewn at the front ends of the fabric with a fastening buckle at front 20. Additionally, stability and positioning retention of hood are ensured by a wire 21 with a diameter of approximately 0.9 mm inserted into a specially sewn cuff at its upper front part. Buttonholes made from paracord are also present on both front and back of poncho where oval wooden/plastic buttons (“tactical toggles”) are threaded and secured corresponding to said buttonholes on hood. [Fig.9] highlights fastening buckle 20, buttonholes, and buttons (“tactical toggles”) for connection to poncho 9 along with wire for shaping hood and a zipper 22 for closing the system.
- [0083] [Fig.10] represents the camouflage pattern scheme for VIS and NIR printing. The upper picture is characterized by an evident “macro pattern”, while the lower picture is characterized by a “micro pattern” lacking of “macro pattern”.
- [0084] In conclusion, it should be understood that this invention has achieved its goal of creating multilayer fabric with camouflage properties across different wavelengths - visible (VIS), near-infrared (NIR), and thermal (TIR) - to confer particular effectiveness and ease of use to a multispectral camouflage garment that is individual,

modular, and multifunctional while also developing specific design configurations. Among identified improvements compared to existing solutions are essential characteristics such as ease of wearability, portability, user-friendliness, lightweight nature, breathability, water-repellency, and versatility for both static and dynamic use in terrestrial and amphibious environments.

Claims

- [Claim 1] 1. A multilayer material (1) for the creation of a multispectral individual camouflage (VIS-NIR-TIR), characterized by comprising:
a sheer/semi-sheer layer (4) with a light transmission level between 20% and 80% equivalent to 80 and 15 deniers, printed with camouflage colors for VIS and NIR with low NIR reflectance (NIR 20% - 40%); and
a coated layer (5), including the following metals:
Copper between 10% and 35%,
Nickel between 2% and 10%,
Aluminum between 5% and 15%,
Silver between 5% and 40%,
Titanium between 5% and 25%.
- [Claim 2] 2. The multilayer material according to claim 1, wherein opposite the sheer/semi-sheer layer (4) is an opaque layer (6), weighing between 80 g/m² and 120 g/m², printed with camouflage colors for VIS and NIR with low infrared reflectance (NIR 20% - 40%).
- [Claim 3] 3. The multilayer material according to claim 1, wherein opposite the sheer/semi-sheer layer (4) is an identical sheer/semi-sheer layer (4).
- [Claim 4] 4. The multilayer material according to claim 1, wherein opposite the coated layer (5), on the side opposite the sheer/semi-sheer layer (4), there are in succession:
• a spacer fabric layer (7), weighing between 100 g/m² and 250 g/m²;
• a coated layer (5); and
• an opaque layer (6).
- [Claim 5] 5. The multilayer material according to the preceding claims, wherein said sheer/semi-sheer layer (4) is made from a fabric selected from the group consisting of polyester, polyamide, viscose, cotton, nylon.
- [Claim 6] 6. The multilayer material according to claim 4, wherein said coated layer (5) is made from a fabric selected from the group consisting of polyester and nylon.
- [Claim 7] 7. The multilayer material according to anyone of claims 2 and 4, wherein said opaque layer (6) is made from a fabric selected

- from the group consisting of polyester, viscose, cotton, nylon, and polyamide.
- [Claim 8] 8. The multilayer material according to the preceding claims, wherein said spacer fabric (7) is made from a fabric selected from the group consisting of carbon fiber fabric and three-dimensional spacer fabric.
- [Claim 9] 9. The multilayer material according to the preceding claims, characterized by a thickness ranging from 0.1 mm to 0.5 mm, with a weight ranging from 120 g/m² to 600 g/m².
- [Claim 10] 10. The multilayer material according to claim 4, wherein said sheer/semi-sheer layer (4) and said opaque layer (6) are suitable to undergo at least one of the treatments of applying micro- and nano-particles selected from materials comprising Silver, Titanium, Carbon, and MXenes.
- [Claim 11] 11. The multilayer material according to claim 4, wherein said sheer/semi-sheer layer (4) and said opaque layer (6) are printed with fractal spot camouflage patterns.
- [Claim 12] 12. A use of the multilayer material according to the preceding claims for creating a multispectral individual camouflage (VIS-NIR-TIR), characterized in that the multispectral individual camouflage (VIS-NIR-TIR) comprises a leg covering (8), a poncho (9), an arm covering (10), a hood (11), a face/weapon covering (12), and a bolero with hood and arm covering (19).
- [Claim 13] 13. The use according to claim 12, wherein the multispectral individual camouflage (VIS-NIR-TIR) has a weight ranging from 1,500 g to 2,500 g.
- [Claim 14] 14. The use according to claim 12, wherein the poncho (9) of the multispectral individual camouflage (VIS-NIR-TIR) includes an opening for the head equipped with a zipper closure (13) to be transformed into a camouflaged covering for static observation posts (VIS-NIR-TIR).
- [Claim 15] 15. The use according to claim 12, wherein the face/weapon covering (12) of the multispectral individual camouflage (VIS-NIR-TIR) is designed to camouflage (VIS-NIR-TIR) the equipment being carried.