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Sound Absorption Properties of Polyether Urethane-Polyanthranilic Acid and Polyvinyl Alcohol-Polyanthranilic Acid Coated Nonwoven Fabrics

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Polieter Üretan-Poliantranilik Asit ve Polivinil Alkol-Poliantranilik Asit Kaplı Dokunmamış Kumaşların Ses Absorbsiyonu Özellikleri

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Abstract

Sound-absorbing textiles have become the subject of numerous studies because; sound absorption and noise reduction using lightweight, simple, and low-cost acoustic materials has become an increasingly important area of research. Nonwoven fabrics are particularly effective in sound absorption due to their random fiber networks, high porosity, adjustable thickness, and low cost; furthermore, polymer coatings are effective in improving the sound absorption performance of nonwoven materials. In this study, multifunctional nonwoven fabrics were produced by coating polyanthranilic acid (PANA)- polyether urethane (TPU) and polyanthranilic acid (PANA)- polyvinyl alcohol (PVA) onto glass (G), polyester (PET), polyester/glass (PET-G), and lyocell (L) fabrics. The study revealed that the structural, sound absorption, and mechanical properties of the coated fabrics were affected by different fabric contents and in the presence of PANA, TPU and PVA. The sound absorption coefficient (SAC) of PANA-PVA coated glass, glass-PET, and lyocell fabric samples were measured as maximum values of 0.32, 0.29, and 0.35, respectively, in the 2000-6300 Hz region. The highest improvement in tensile strength was measured in PANA-TPU and PANA-PVA coated lyocell fabrics (4PUC: 16.97 N ± 0.95 and 4PVAC: 12.97 N ± 1.05). In addition, one-way analysis of variance (ANOVA) indicated that the differences in tensile strength properties according to the type of coated polymer were statistically significant for all samples ($p < 0.001$).

Keywords: *Polyanthranilic acid; Polyether urethan; polyvinyl alcohol; Glass; Lyocell; Sound absorption.*

Öz

Günümüzde, ses absorpsiyon tekstilleri ile ilgili; ses emilimini arttıran, gürültüyü azaltan, düşük maliyetli ve hafif akustik malzemelerin kullanımının giderek daha önemli bir araştırma alanı haline gelmesi nedeniyle, çok sayıda çalışma yapılmaktadır. Dokunmamış kumaşlar, rastgele lif ağları, yüksek gözeneklilik, ayarlanabilir kalınlık ve düşük maliyet özellikleri nedeniyle ses emiliminde iyi performans göstermektedir; ayrıca polimer kaplamaları da dokunmamış tekstil yüzeylerinin ses emilim performansını iyileştirmede etkili bir yöntemdir. Bu çalışmada, polieter üretan (TPU)-poliantranilik asit (PANA) ve polivinil alkol (PVA)-poliantranilik asit (PANA) kompozitlerinin cam (G), polyester (PET), poliester/cam (PET-G) ve liyosel (L) dokunmamış yüzeylere kaplanması ile çok fonksiyonlu dokunmamış tekstil yüzeyleri üretilmiştir. Üretilen yüzeylerin yapısal, ses absorpsiyonu ve mekanik özellikleri incelendiğinde kaplanan malzeme türünün ve kumaş içeriğinin ses emme ve mekanik özellikler üzerinde etkili olduğu gözlemlenmiştir. PANA-PVA kaplı cam, cam-PET ve liyosel kumaş örneklerinin ses absopsiyon katsayıları (SAC) 2000-6300 Hz bölgesinde sırasıyla; 0,32, 0,29 ve 0,35 maksimum değerleri olarak ölçülmüştür. Çekme dayanımındaki en yüksek iyileşme PANA-TPU ve PANA-PVA kaplı liyosel kumaşlarda ölçülmüştür (4PUC: 16,97 N ± 0,95 ve 4PVAC: 12,97 N ± 1,05). Ayrıca, tek yönlü varyans analizi (ANOVA), kaplanan polimer türüne göre çekme dayanımı özelliklerindeki farklılıkların tüm örnekler için istatistiksel olarak anlamlı olduğunu ortaya koymuştur ($p < 0,001$).

Anahtar Kelimeler: *Poliantranilik asit; Polieter-üretan; Polivinil alkol; Cam; Liyosel; Ses absorbsiyonu.*

1. Introduction

Multifunctional textiles, such as sound absorption textiles, have received much attention in research studies and daily life, due to technological and environmental developments and consumer behavior (Feng and Liu 2025, Tang and Yan 2017). Sound absorption properties of textile materials play a significant role in the material engineering of protective clothing, insulating materials, transportation composites, etc. Sound is a mechanical wave resulting from pressure fluctuations in an elastic medium. Noise is defined as unwanted or harmful sound that interferes with communication and comfort in daily life and may adversely affect human physical and mental health and well-being. Also, high-intensity noise may cause the aging of mechanical equipment and cause harm to buildings. So, noise pollution has been ranked as one of the environmental hazards, along with other forms of pollution. Therefore, nowadays sound absorption and noise reduction with lightweight, simple, and low-cost acoustic materials have gradually become an important

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research area (Feng and Liu 2025, Zhang et al. 2024). The behavior of sound waves depends on the type of surface they interact with, and sound waves can be absorbed, transmitted, reflected, or scattered by materials (Fink 2025, Paul et al. 2021).

The sound absorption coefficient (SAC) is used to determine a material's sound absorption level, with values ranging between 0 and 1(Hassan et al. 2021).

The sound waves with low frequency can be absorbed more difficult than high-frequency waves by materials. The sound absorption can be measured by two methods: the reverberation chamber and impedance tube methods, according to the sample size. The impedance tube method needs a smaller sample size. Based on SAC, the sound absorption performance is classified into 6 classes, A, B, C, D, E, and F from best ranks to worst, respectively (ASTM, 1990, Paul et al. 2021).

Numerous studies have shown that nonwovens can be engineered to achieve high absorption over specific frequency bands. Fibrous nonwoven fabrics are particularly effective in sound absorption because of their random fiber network, high porosity, adjustable thickness, and low-cost features. These properties determine the magnitude of the sound absorption coefficient. (Seddeq 2009 Paul et al. 2025, Olhan et al. 2021)

Over the years, many researchers reported different methods to produce nonwoven fabrics with sound absorption properties. Among various processes, coating nonwoven surfaces with a polymer layer is a suitable method for industrial-scale processes because of its simplicity and feasibility (Chen et al. 2016, Feng and Liu 2025, Paul et al. 2021, Tang and Yan 2017, Usta et al. 2025, Wang and Tang 2023). Because polymer coatings are very effective at improving sound absorption performance of textile materials. Incident sound waves cause vibration of the polymer layer, which can convert sound energy into vibration and film friction to achieve sound absorption (Zhang et al. 2024).

Three different types of fibers (glass, polyester, and lyocell) were chosen for this experimental study. Glass fiber is an inorganic fiber widely used in many applications such as textile, construction, automotive, and aerospace. Because glass is a lightweight material that has a high sound absorption effect, excellent durability, and mechanical properties, is not easily affected by humidity, temperature, and other factors, and has a long service life (Aslan 2025;Miracle et al. 2001; Nazari et al. 2025). Besides, polyethylene terephthalate (PET) fibers are the most used fiber in the textile industry due to the excellent properties like mechanical and sound absorption performance (Aydemir et al. 2025, Hu et al. 2024). Lyocell, a regenerated cellulose-based textile fiber, was used in this research because it has the most environmentally friendly regenerated cellulose production process, is easily degradable, and has good mechanical properties (Madushika and Lanarolle 2022).

These nonwoven fabrics were coated with three different types of polymers. Polyvinyl alcohol (PVA) has become a popular component in sound absorption materials because it is non-toxic, water-soluble, biodegradable, with good film-forming ability, high porosity potential and compatibility with other functional fillers (Peng et al. 2023, Shen et al. 2022, Yu et al. 2025, Zhu and Tang 2024). Polyurethane (PU) has been widely used as a coating material in the material industry, such as textiles, breathable films, automotive, etc. (Aslan 2025) Thermoplastic polyurethane (TPU) is used as a second polymer because of its sound absorption performance, good mechanical and chemical properties, and durability (González-García et al. 2025, Karaca et al. 2022; Oğlakcıoğlu et al. 2021). Polyaniline (PANI) and its derivatives are considered to be one of the most promising classes of conducting polymers due to their excellent properties (Feng and Liu, 2025, Yuan et al. 2024). The carboxyl functionalized PANI "polyanthranilic acid" (PANA) is one of the derivatives of PANI with good solubility and mechanical properties (Khalil et al. 2013, McCormick et al. 2024).

In this study, polyanthranilic acid was produced by chemical polymerization processes, then polyanthranilic acid-polyether urethane and polyanthranilic acid-polyvinyl alcohol composites were prepared and coated onto nonwoven fabrics with 4 different contents (glass, polyester, polyester/glass, and lyocell) by drop casting method. Then the structural, mechanical, and sound absorption properties of these samples were investigated, respectively.

Most previous studies have reported the sound absorption properties of nonwoven fabrics with higher area densities and nonwoven fabrics coated with thermoplastic polymers and common conductive polymers; however, PANA and the combined effect of PANA-TPU and PANA-PVA on sound absorption and mechanical behavior have received limited attention. This study distinguishes itself from most current acoustic textile research by systematically investigating three lightweight, wet-laid nonwoven fabrics (glass, polyester, and lyocell) under the same PVA, TPU, and PANA coating

conditions. The present research study objectives are to reduce weight, energy and cost by developing novel multifunctional PANA, TPU, and PVA-coated fabrics with improved mechanical behavior and sound absorbing properties through the combination of TPU and PVA with PANA. Furthermore, this study aims to evaluate the interaction of PANA, TPU, PVA, and fabrics and determine their synergistic effects on sound absorbing properties. It demonstrates that the integration of a conductive polymer provides multifunctionality while maintaining low weight and offers a more material-efficient and performance-oriented strategy for improving mid-to-high frequency acoustic behavior in thin nonwoven structures. These novel and sustainably advanced multifunctional fabrics can be used in technical textile applications.

2. Materials and Methods

2.1. Material

Shape-memory polyether urethane (TPU) was obtained from DIAPLEX MM 3520, SMP Technologies Inc., Tokyo, Japan, 3-aminobenzoic acid (98%), sodium hydroxide (NaOH), ammonium persulfate (APS) and polyvinyl alcohol (PVA) (molecular weight MW = 70,000 g/mol) were purchased from Sigma Aldrich. Acetic acid, tetrahydrofuran (THF) and N,N-Dimethylformamide (DMF) were obtained from Merck Company (Germany). All chemicals were used without further purification. Undyed wet laid and spun lace 50g/m^2 area density nonwoven fabrics with different contents (100% PET, 100% Glass, and 100% Lyocell) and 130 g/m^2 50-50% Glass- PET fabrics were used as the base structure during the study.

2.2. Preparation of TPU-PANA and PVA- PANA

2.2.1. Preparation of TPU and PVA solutions

25 ml DMF and 25 ml THF were mixed, then 5g polyether urethane was added to that mixture and dispersed by stirring at 50 °C for 60 min. Then the solution was cooled for 30 min at room temperature by stirring.

5g polyvinyl alcohol was dispersed in a mixture that includes 45 ml acetic acid and 5 ml of distilled water, by stirring at 70 °C for 60 min. Then the solution was cooled for 30 min at room temperature by stirring.

2.2. 2.Preparation of PANA

1.499 g NaOH and 5 g 3-Aminobenzoic Acid were dissolved in 65 ml of distilled water and stirred for 2 h at room temperature. That process was followed by adding 9 g APS, dissolved in 35 ml of distilled water, to the mixture. The polymerization was continued for 1 h at room temperature. Then the mixture was centrifuged, and the products were dried for 24 h at room temperature.

2.2.3 Preparation of TPU-PANA and PVA-PANA mixture

5g PANA was dispersed in 50 ml (50-50%) THF–DMF, and 5g PANA was dispersed in 50 ml (90-10%) acetic acid - distilled water. The mixtures were added to TPU and PVA solutions, respectively, and stirred for 10 min at room temperature.

2.3 Preparation of TPU-PANA- Nonwoven fabrics and PVA-PANA- Nonwoven fabrics.

The prepared composite was coated on both sides of the nonwoven fabrics (PET, Glass, Glass- PET, and Lyocell) one by one via the drop casting method. The coated fabrics were dried at room temperature for 24 h.

Table 1. Samples with various contents

Samples	Content
1R	Untreated Glass Fabric
2R	Untreated Polyester Fabric
3R	Untreated Polyester/Glass Fabric
4R	Untreated Lyocell Fabric
1C	PANA-Glass Fabric
2C	PANA-Polyester Fabric
3C	PANA -Polyester/Glass Fabric
4C	PANA-Lyocell Fabric
1PU	TPU- Glass Fabric
2PU	TPU- Polyester Fabric
3PU	TPU- Polyester/Glass Fabric
4PU	TPU- Lyocell Fabric
1PVA	PVA- Glass Fabric
2PVA	PVA- Polyester Fabric
3PVA	PVA- Polyester/Glass Fabric
4PVA	PVA- Lyocell Fabric
1 PUC	PANA/TPU/Glass Fabric
2 PUC	PANA/TPU/ Polyester Fabric
3 PUC	PANA/TPU/ Polyester/Glass Fabric
4 PUC	PANA/TPU/Lyocell Fabric
1 PVAC	PANA/PVA/ Glass Fabric
2 PVAC	PANA/PVA/ Polyester Fabric
3 PVAC	PANA/PVA/ Polyester/Glass Fabric
4 PVAC	PANA/PVA/Lyocell Fabric

2.4. Characterization

The developed nonwoven composite fabrics were individually tested and analyzed in order to comprehensively understand their properties. Prior to testing, test specimens were conditioned (20±2˚C,65±2% relative humidity, 24 hours).

The FTIR–ATR spectrophotometric analysis of fabrics was carried out by an FT-IR reflectance spectrophotometer (Perkin Elmer, Spectrum One, with a Universal ATR attachment with a diamond and ZnSe crystal).

Sound absorption coefficient measurements were performed on 30 mm diameter samples using a “Brüel & Kjær” impedance tube in the 500–6300 Hz frequency

range, in accordance with the TS EN ISO 10534-2 standard.

The tensile properties of the fabrics were measured by the Instron 4411 test device in accordance with the ISO 9073-3: 2023 standard from the longitudinal directions and fabric thickness were measured according to the BS EN ISO 5084.

3. Results and Discussions

3.1. FTIR-ATR Spectrophotometric Analysis

The IR spectra of the samples are given in Figure 1. These IR spectra confirm the presence of polyanthranilic acid, polyether urethane, and polyvinyl alcohol on the surface of the nonwoven fabrics.

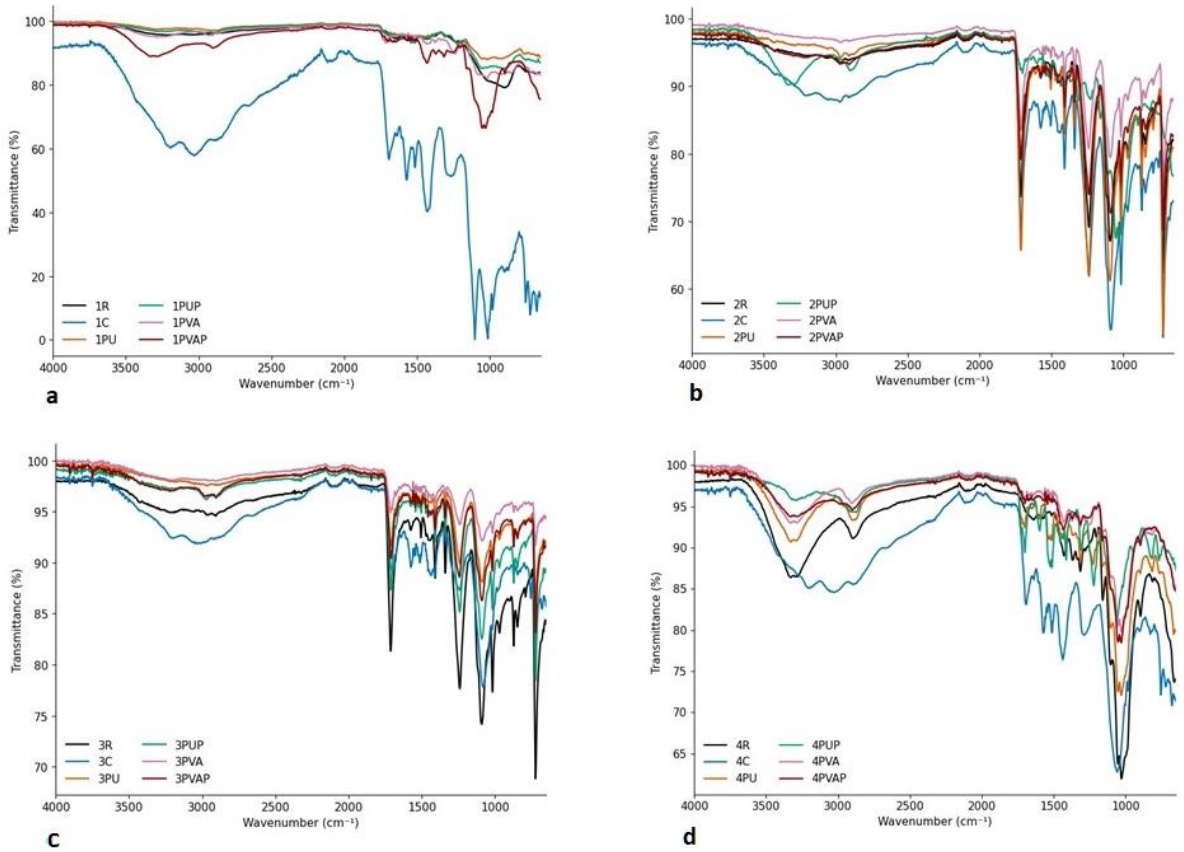

Figure 1. a) FTIR spectrum of the glass fabrics; (1R), (1PU), (1PVA), (1C), (1PUC), (1PVAC); b) FTIR spectrum of the polyester fabrics; (2R), (2PU), (2PVA), (2C), (2PUC), (2PVAC); c) FTIR spectrum of the polyester-glass fabrics; (3R), (3PU), (3PVA), (3C), (3PUC), (3PVAC); d) FTIR spectrum of the lyocell fabric; (4R), (4PU), (4PVA), (4C), (4PUC), (4PVAC)

Figure 1a-d showed that the FTIR spectra results confirm the successful incorporation of PANA, TPU, and PVA with fabrics (enhanced C=O and C–O–C peaks) and indicate potential hydrogen bonding interactions. A broad absorption band around 3200–3500 cm^{-1} is attributed to the stretching vibration of hydroxyl groups (–OH) for PVA and stretching of the N-H group for TPU. This peak broadens due to hydrogen bonding interactions between TPU-PANA and PVA-PANA and fabrics (González-García et al., 2025; McCormick et al., 2024; Shen et al., 2022; Yuan et al., 2024).

The carbonyl bands in the 1700–1730 cm^{-1} region occur in all samples. The intensity of peak changes due to the coated fabric type; the lower intensities were observed from glass fabric substrates. The hydrogen bonding between the PANA-TPU and PANA-PVA macromolecules might be determined from the intensity and band-shape/position changes for the CH2, C–NH, C=O, and C–O bonds and the width of the OH absorption bands (Gavrilenko & Wang, 2019; Moiz et al., 2017).

3.2. Sound Absorption Analysis

The sound absorption coefficient spectra of the samples are presented in Figure 2 a-d. The results showed that in the frequency range 500–1000 Hz, the coefficients are generally ~ 0.10 and ~ 0.20, with variations among the TPU, PVA, and PANA contents, indicating limited dissipation of acoustic energy in this band.

At higher frequencies, the behavior of the PANA-PVA sample clearly shows higher sound absorption properties for glass, glass-PET, and lyocell fabrics from 2000 Hz to 6300 Hz, with the maximum values 0.32,0.29, and 0.35, respectively.

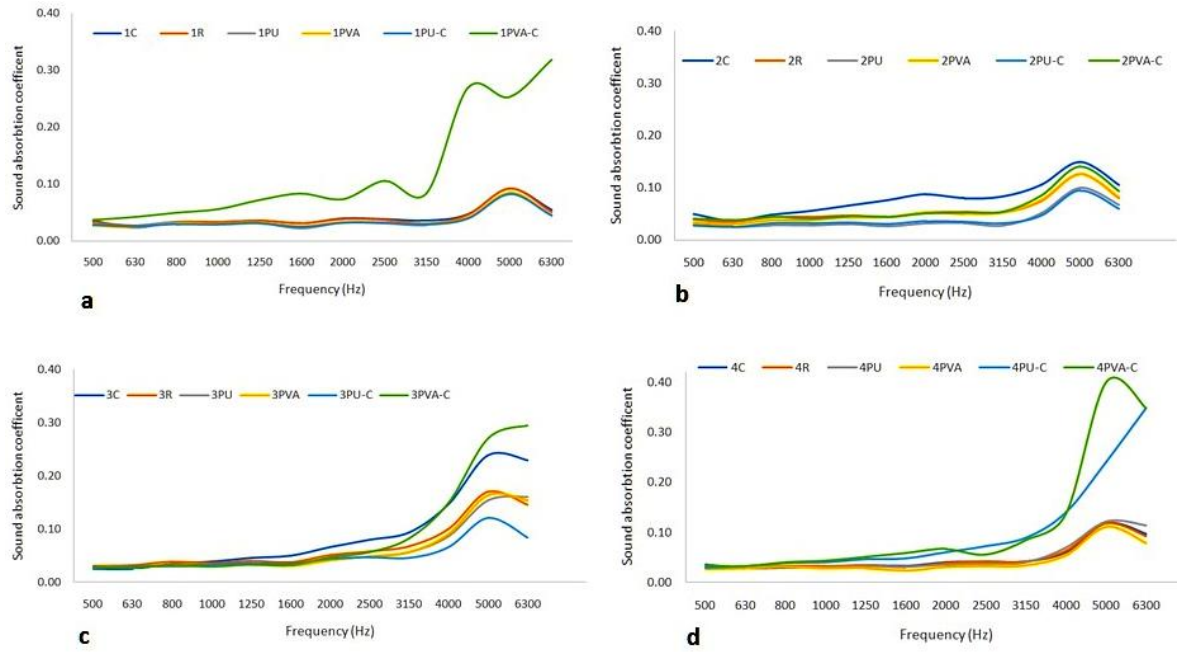

Figure 2. Sound absorption properties of a) untreated and treated glass fabrics, b) untreated and treated polyester fabrics, c) untreated and treated polyester-glass fabrics, d) untreated and treated lyocell fabrics.

These high-frequency enhancement suggests that the incorporation of PANA into the PVA-based system introduces additional loss mechanisms (e.g., increased internal friction and interfacial damping), which are more effective at short acoustic wavelengths (Aydemir et al. 2025, González-García et al. 2025, Karaca et al. 2022; Zhu and Tang 2024). Also, the results showed that PANA content increased sound absorption properties for all samples (Gao et al. 2016, Shen et al. 2022, Yuan et al. 2024). So, the results indicate that the samples with PVA and PANA contents provide the most favorable sound absorption performance for this study, especially for high frequency ranges, whereas the unmodified and TPU-based samples are acoustically less efficient across the spectrum. The treated non-woven fabrics have low sound absorption performance at mid-frequencies, and slightly better at high frequencies (>1000 Hz) than at mid-frequencies. The enhancement of sound absorption in the 4000–6300 Hz region might suggest that the coating primarily affects viscous dissipation mechanisms rather than acting as a mass barrier. (Seddeq 2009, Paul et al. 2025, Olhan et al. 2021, Çelikel and Babaarslan 2017.) So, in this study, medium level, sound absorption performance has been obtained from PVA-PANA and TPU-PANA coated fabrics. (Gao et al. 2016, Karaca et al. 2022; Zhu and Tang 2024)

3.3. Mechanical Properties Analysis

The mechanical properties of the samples were given in Figure 3a-b. The mechanical properties of glass (1C: 18.63 N ± 0.40, 1PU: 21.50 N ± 0.50),polyester (2C: 23.00 N ± 1.00, 2PU: 22.37 N ± 0.55, 2PVAC: 26.00 N ± 0.60) and polyester-glass fabrics (3C: 37.93 N ± 1.90, 3PU:25.26 ± 0.93, 3PVAC: 32.20 ± 1.11) improved with PANA, TPU and PANA-PVA (except for glass fabric) content , while decreased by PVA content especially for glass and PET/glass fabrics(1PVA: 3.03 N ± 0.15, 3PVA: 22.50 N ± 0.50) (Figure 3a).(Feng and Liu 2025, González-García et al. 2025, Hu et al. 2024, McCormick et al. 2024, Shen et al. 2022, Zhu and Tang 2024).

On the other hand, Figure 3a revealed that improved strength properties of lyocell fabrics were observed in the presence of TPU-PANA and PANA-PVA content, which might have occurred due to the new hydrogen bonds (Figure1a-d). Among the coated samples, PANA-TPU and PANA-PVA coated lyocell fabrics showed the highest tensile strength improvement (4PUC: 16.97 N ± 0.95, and 4PVAC: 12.97 N ± 1.05), indicating that the combined PANA and TPU and PVA coating might enhance fiber–fiber interactions and coating–substrate adhesion. (González-García et al. 2025, McCormick et al. 2024, Shen et al. 2022). Also, the PVA-PANA samples exhibited reduced strain performance, which may have occurred due to excessive coating stiffness. (Figure 3b)

The statistical analysis of the tensile strength results was examined. A one-way analysis of variance (ANOVA) revealed that the differences among the groups were statistically significant for glass, PET, PET/glass and lyocell fabrics ($p < 0.001$). These findings indicate that the coated material significantly affected the tensile strength of the samples. So, the results clearly demonstrate that the mechanical performance of the fabrics was strongly dependent on the applied polymer type.

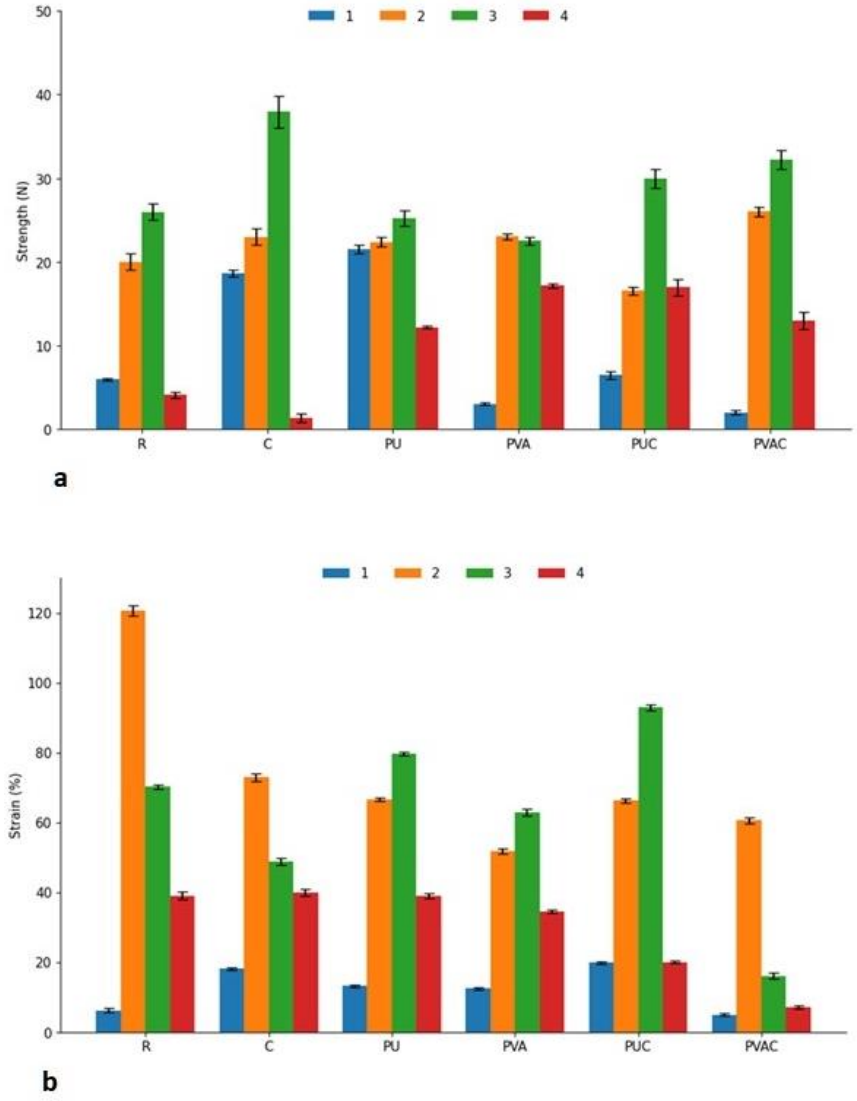

Figure 3. a) Strength and b) strain properties of 1) Glass fabrics, 2) Polyester fabrics, 3) Polyester-glass fabrics, 4) Lyocell fabrics.

In the glass fabrics, TPU-coated fabrics exhibited the highest tensile strength values, whereas PVA and PVA-PANA coated samples showed comparatively lower performance. In the PET and PET/glass fabrics, a general increase in tensile strength was observed, especially with PANA and PVA-PANA coatings; this suggests a possible improvement in the coated polymer-fabric interaction.(González-García et al. 2025, McCormick et al. 2024, Shen et al. 2022). Notably, for the PET/glass fabrics, the PANA coated fabric showed the highest tensile strength, which might suggest enhanced structural reinforcement. In contrast, for lyocell fabrics, there is an overall reduction in strength values obtained with only PANA coating.

Overall, the consistent statistical significance across all series confirms that the coated polymer type plays a decisive role in determining tensile strength performance. The variations among TPU, PVA, TPU-PANA, and PVA-PANA systems suggest that both polymer matrix characteristics influence stress distribution and mechanical reinforcement behavior.

3.4 Thickness and weight analysis

Thickness and weight increase show coating efficiency. So, thickness and weight variations were given in Figure 4 a and b for all samples. The results showed that TPU-PANA and PVA-PANA content increased the thickness and weight dramatically. The coating add-on values were approximately higher than 100% for TPU-PANA and PVA-PANA coated fabrics. Besides, the thickness increases of fabrics are approximately 0.3 mm for TPU-PANA and PVA-PANA coated fabrics. The findings revealed that sound absorption properties might be related to coating add on and thickness. The sound absorption coefficient might be slightly increased with thickness, especially for low frequencies, but the progressive increase in SAC for high frequencies with increasing coating add-on further supports a microstructural dissipation mechanism rather than a thickness effect. The observed SAC improvement

might be related to increased microstructural stiffening introduced by the PVA-PANA layer. In thin porous materials, high-frequency absorption is strongly governed by pore geometry and internal friction effects, where even moderate pore narrowing can significantly enhance viscous losses rather than a simple increase in thickness or mass. (Seddeq 2009, Paul et al. 2025, Olhan et al. 2021, Çelikel and Babaarslan 2017, Zhang et al. 2024).

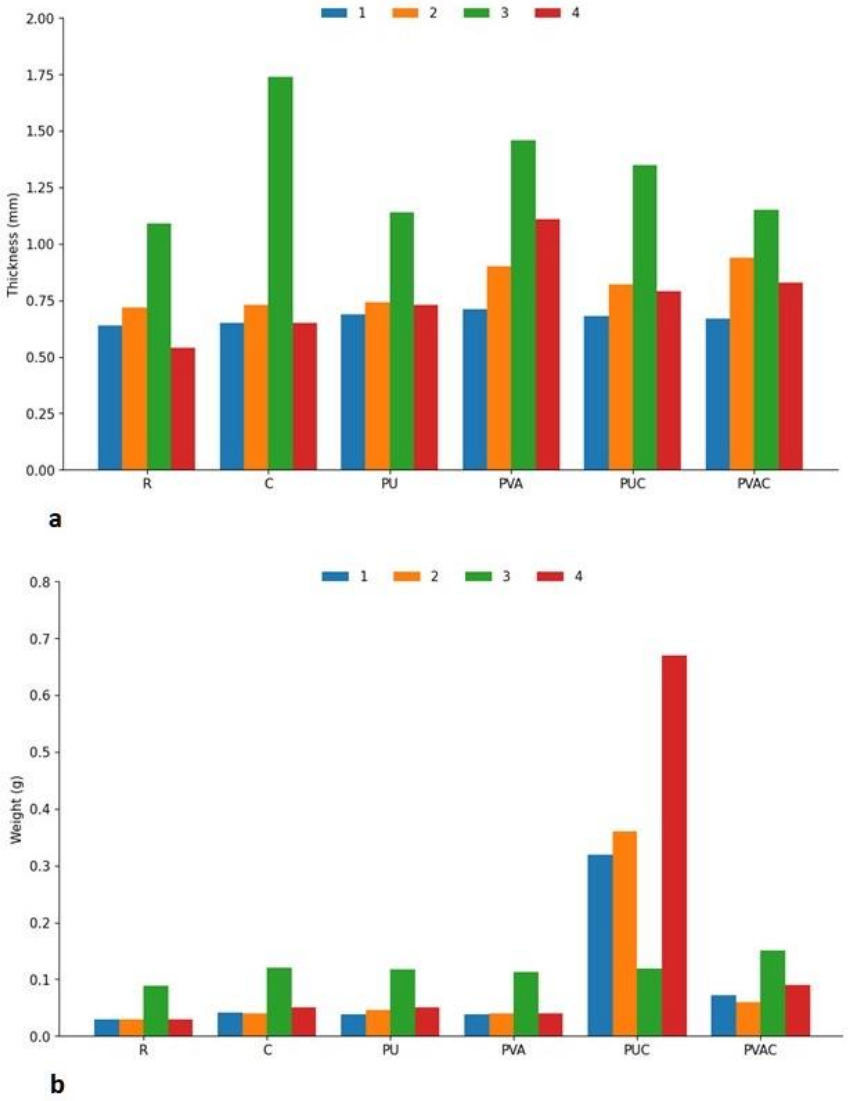

Figure 4. a) Thickness and b) weight values of 1) Glass fabrics, 2) Polyester fabrics, 3) Polyester-glass fabrics, 4) Lyocell fabrics.

4. Conclusions

In this study, sound absorption and mechanical properties of PANA-TPU and PANA-PVA coated nonwoven fabrics were investigated. For that aim, polyanthranilic acid produced by chemical polymerization processes, then polyanthranilic acid- polyether urethane and polyanthranilic acid - polyvinyl alcohol composites were prepared and coated onto nonwoven fabrics with 4 different contents (glass, polyester, polyester/glass, and lyocell) by drop casting method. Then the structural, mechanical, and sound absorption properties of these samples were investigated, respectively.

Structural properties of samples were investigated by FTIR analysis, and the results confirm the successful incorporation of PANA, TPU, and PVA with fabrics and indicate potential hydrogen bonding interactions. Besides, the mechanical properties of glass (1C: 18.63 N ± 0.40, 1PU: 21.50 N ± 0.50),polyester (2C: 23.00 N ± 1.00, 2PU: 22.37 N ± 0.55, 2PVAC: 26.00 N ± 0.60) and polyester-glass fabrics (3C: 37.93 N ± 1.90, 3PU: 25.26 ± 0.93, 3PVAC: 32.20 ± 1.11) improved with PANA, TPU and PANA-PVA (except for glass fabric) content , while decreased with PVA content, especially for glass and PET/glass fabrics(1PVA: 3.03 N ± 0.15, 3PVA: 22.50 N ± 0.50). Also, PANA-TPU, and PANA-PVA coated lyocell fabrics showed the highest tensile strength improvement (4PUC: 16.97 N ± 0.95, and 4PVAC: 12.97 N ± 1.05). When the tensile strength results of all four fabric types were evaluated collectively, statistically significant differences were observed among the coating materials in each series ($p < 0.001$ for all sets). So, the coated polymer type plays a decisive role in determining tensile strength performance.

Sound absorption coefficient results indicate that the samples with PVA and PANA contents provide the most favorable sound absorption performance for this study in the high frequency range, whereas the unmodified and TPU-based samples acoustically less efficient across the spectrum. The coated nonwoven fabrics have a moderate sound absorption performance, being lower in the mid-frequencies and slightly better in the high frequencies (>1000 Hz) compared to the mid-frequencies.

The coating add-on values were approximately higher than 100% for TPU-PANA and PVA-PANA coated fabrics. Besides, the thickness increases of fabrics are approximately 0.3 mm for TPU-PANA and PVA-PANA coated fabrics. Therefore, sound absorption properties might be slightly increased related to weight increment and thickness, especially for low frequencies. On the other hand, the improvement in sound absorption was predominantly observed in the 4000–6300 Hz range (up to 0.30); it might be related to increased microstructural stiffening introduced by the PVA-PANA layer.

The study revealed that PANA, TPU, and PVA content and fabric type have an impact on the mechanical and sound absorption properties.

Declaration of Ethical Standards
The author declare that they comply with all ethical standards.

Credit Authorship Contribution Statement
Author-1: Conceptualization, investigation, methodology and software, supervision and writing – original draft-review and editing.

Declaration of Competing Interest
The authors have no conflicts of interest to declare regarding the content of this article.

Data Availability Statement
All data generated or analyzed during this study are included in this published article.

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