

REVIEW ARTICLE

Acoustic Absorption in Woven and Nonwoven Interior Textiles: A Critical Synthesis of Structure-Property Evidence

Reconciling contradictory findings across weave, fibre blend, and multilayer assemblies

JAT Editorial Office

academic@curtains.vip

ABSTRACT

Interior textiles are increasingly specified for acoustic comfort, yet the evidence base for woven and nonwoven absorbers is fragmented and partly contradictory. This critical synthesis examines ten supplied studies to clarify how fibre type, yarn structure, weave architecture, fabric density, layering, and composite processing govern sound absorption. Nonwoven evidence is comparatively consistent: needle-punched blends of natural and synthetic fibres absorb well, with thickness, areal density, air permeability, and pore size acting as recurring predictors [5][10]. Woven evidence is less settled. One study reports no significant correlation between absorption and thickness, surface density, or porosity, implying a mechanism distinct from felt-like aggregates [1], while others find that yarn type, weave, thread density, and incidence angle materially change performance [3][6][7]. Multilayer and hybrid assemblies-woven facings over nonwoven cores, microfibre resistive layers, microcapsule doping, and perforated foam-fabric combinations-can raise absorption toward unity at targeted frequencies, but outcomes depend on cavity backing, layer count, and test configuration [2][3][4][6][8]. Three-dimensional woven fabrics and their composites show fibre-dependent behaviour, with jute and flax outperforming glass and resin infusion reducing absorption [9]. The synthesis identifies porosity descriptors, airflow resistance, and membrane-type responses as candidate unifying variables, but notes that measurement methods, frequency ranges, and backing conditions differ across studies, limiting direct comparison. Practical implications centre on specifying assemblies rather than single fabrics, controlling air permeability, and validating performance under intended mounting conditions.

Keywords: sound absorption; woven fabrics; nonwoven textiles; interior acoustics; air permeability; multilayer assemblies; impedance tube; textile manufacturing

SECTION 01

Why woven and nonwoven absorbers cannot be treated as one evidence class

Interior noise control is a recurring driver for textile specification, and the supplied literature approaches it from two largely separate traditions. Nonwoven studies tend to treat the material as a porous fibre aggregate whose absorption is governed by thickness, density, airflow resistance, and pore architecture [5][10]. Woven studies, by contrast, must contend with a periodic interlaced architecture in which yarn crimp, float length, and inter-yarn gaps create a pore network that is not simply a scaled version of a fibrous web [1][7]. This distinction matters because it predicts where evidence should converge and where it should not. If absorption in both classes were controlled by the same porosity descriptors, we would expect thickness and surface density to correlate with performance across the board. The supplied evidence does not support that expectation uniformly.

A second reason to avoid treating the two classes as one is that their typical application roles differ. Nonwovens are often the bulk absorber, while wovens are frequently proposed as facings, resistive layers, or decorative surfaces that modify an underlying absorber [3][6][8]. That functional division means a woven fabric may be evaluated not for its standalone absorption but for its effect on an assembly. Studies that measure only the fabric, and studies that measure the fabric-plus-core, therefore answer different questions and should not be pooled uncritically. The synthesis below keeps that distinction explicit.

A third consideration is measurement context. The supplied studies variously use impedance tubes, an anechoic chamber, and a purpose-built sound absorption tester, and they report different frequency ranges and backing conditions [1][2][4][5][7][10]. Because absorption is strongly sensitive to mounting, cavity depth, and incidence angle, apparent disagreements between studies may reflect test configuration rather than material behaviour. This is not a reason to dismiss the evidence, but it is a reason to read each result as conditional on its measurement setup.

SECTION 02

Nonwoven evidence: thickness, permeability, and blend effects

The nonwoven literature supplied here is the more internally coherent body of work. Boominathan et al. produced twelve needle-punched nonwovens from *Sansevieria stuckyi*, banana, hemp, and their blends, and reported that blended fibre mats achieved higher sound absorption coefficients than mono-fibre mats, with higher hemp proportion and greater thickness yielding maximum absorption [5]. They also identified air permeability, porosity, and thermal conductivity as influencing absorption [5]. Velayutham et al. similarly developed needle-punched nonwovens from kapok, jute, flax, viscose, polyester, polypropylene, and recycled PET, and found that 100% kapok fabric, characterised by a compact structure, higher thickness, lower air permeability, and smaller average flow diameter, outperformed the other samples for automotive interior noise control [10].

Read together, these two studies converge on a practical hierarchy: thickness and compaction, mediated through airflow resistance and pore size, are the dominant levers in needle-punched nonwovens [5][10]. The agreement is notable because the fibre sets differ substantially—one emphasises hemp-rich blends, the other kapok—suggesting that the controlling variables are structural rather than botanical. That said, both studies rely on a limited set of fibre types and a single manufacturing route, needle punching. Extrusion-based, spunbond, and meltblown nonwovens may exhibit different pore networks and are not represented in the supplied evidence.

The nonwoven findings also carry an important caveat about interpretation. Air permeability and porosity are correlated with thickness and compaction, so the reported influence of each variable is not independent. Neither study appears to isolate airflow resistance from thickness experimentally. The practical implication is that specifying a thicker, denser nonwoven is a reliable direction of travel, but the precise mechanism—whether resistance, tortuosity, or pore-size distribution dominates—remains unresolved by the supplied sources.

SECTION 03

Woven evidence: a genuine disagreement about controlling variables

The woven literature supplied here contains a direct and instructive conflict. Li et al. wove plain, twill, and honeycomb fabrics at identical warp density and measured them by impedance tube, concluding that there was no significant correlation between sound absorption and fabric thickness, surface density, or porosity [1]. They argued that the absorption mechanism in woven fabrics may differ from that in felts and nonwovens, and that pore size and shape, rather than porosity alone, may be important [1]. This is a strong claim: it implies that the descriptors that work well for nonwovens [5][10] do not transfer to wovens.

Other woven studies, however, report that structural variables do matter. Segura-Alcaraz et al. found that woven fabrics with different warp and weft counts, placed as resistive layers on a polyester nonwoven, efficiently modified the assembly's absorption, with appropriate thread-density combinations producing coefficients close to 1 at selected frequencies [3]. In a later multilayer study, the same group reported that for a given fabric density, absorption increased as the number of layers

decreased, and they modelled the influence of weft count and nonwoven thickness [6]. Samuel et al. prepared sixteen woven fabrics from textured, twisted, and staple polyester yarns in plain, rib, sateen, and twill weaves, and found that textured polyester yarns gave higher absorption and that acoustic incidence angle influenced measured performance [7].

The disagreement is partly reconcilable. Li et al. measured standalone woven fabrics and varied weave type at fixed warp density [1]; Segura-Alcaraz et al. measured wovens as facings on a nonwoven core [3][6]; Samuel et al. varied yarn type and incidence angle [7]. These are different experimental objects. A standalone thin woven fabric may indeed show weak dependence on thickness and density because its absorption is modest and dominated by other effects, whereas a woven facing can strongly modulate a core's impedance. The unresolved question is whether Li et al.'s null result reflects a genuine mechanism difference or the limited range of their structural variation. The supplied sources do not settle this.

SECTION 04

Hybrid and multilayer assemblies: where the largest gains appear

The most consistent practical message across the supplied sources is that combining materials outperforms single fabrics. Segura-Alcaraz et al. demonstrated that a microfibre woven fabric used as an upstream layer improved the absorption of a polyester nonwoven, producing a material suited to the frequencies of the human voice [8]. The same research group showed that woven facings with 15-30 ends/cm and picks/cm could push a simple polyester nonwoven toward absorption coefficients near 1 at different frequencies by selecting the appropriate warp and weft combination [3]. Their multilayer study extended this to fabrics with 60 ends/cm and varying picks/cm, finding that absorption increased as layer count decreased for a given fabric density [6].

Beyond woven-over-nonwoven systems, two further hybrid routes appear. Atienzar-Navarro et al. doped cotton woven fabrics with microcapsules by padding and found that the change in absorption coefficient depended on fabric type, microcapsule concentration, and whether the sample was backed by an air cavity or a rigid wall [2]. The same first author, in a separate study, drilled recycled polyurethane foams with cylindrical perforations at 5% and 20% rates and 4 mm and 6 mm apertures, then combined them with fabrics; fabrics with a membrane-type acoustic response modified absorption at mid frequencies [4]. These results broaden the design space but also show that outcome depends on backing and perforation geometry, not on the textile alone.

Three-dimensional woven structures add a further dimension. Paul et al. studied 3D woven orthogonal fabrics and their composites, reporting that jute and flax orthogonal fabrics outperformed glass fabrics acoustically, that air porosity and airflow resistance correlated with absorption, and that epoxy resin infusion reduced absorption in the composites [9]. This is consistent with the broader theme that adding a solid matrix or reducing open porosity tends to suppress absorption, while retaining open, tortuous pathways favours it.

SECTION 05

Candidate unifying variables and where the evidence remains thin

Across the supplied studies, three candidate unifying variables recur. The first is airflow resistance or its proxies—air permeability, porosity, and pore size. Nonwoven studies explicitly link lower air permeability and smaller flow diameter to better absorption [10], and 3D woven work correlates airflow resistance with absorption [9]. Li et al.'s emphasis on pore size and shape rather than porosity alone is compatible with this, even though they found no correlation with bulk porosity [1]. The second is thickness and compaction, which dominate the nonwoven evidence [5][10] but are contested for wovens [1][6]. The third is membrane-type or resistive-layer behaviour, invoked to explain why thin woven facings can markedly change an assembly's response [4][8].

These candidates are plausible but not yet integrated. No supplied study measures airflow resistance and pore-size distribution across both woven and nonwoven families under identical conditions. The frequency ranges also differ: some work spans low to medium frequencies [7], others 0-4000 Hz [5], and others focus on mid frequencies or voice frequencies [4][8]. Because absorption is frequency-dependent and mounting-sensitive, cross-study comparison of coefficients is hazardous. The honest

position is that the field has identified likely controlling variables but has not established a single predictive framework.

A further gap concerns durability and real-service performance. The supplied sources report laboratory acoustic measurements; none examines how absorption changes with cleaning, compression, humidity, or long-term soiling in interior applications. For product developers, this is a material omission, because interior textiles are routinely cleaned and compressed.

SECTION 06

Implications for applied textile design and manufacturing

For interior textile specification, the evidence favours designing assemblies rather than selecting single fabrics. A woven facing over a nonwoven core can achieve high absorption at targeted frequencies when thread density and core thickness are chosen together [3][6], and a microfibre woven layer can extend performance into voice frequencies [8]. Developers should therefore treat the facing, core, and mounting cavity as one system and validate it under the intended backing condition, since air-cavity versus rigid-wall backing changes measured outcomes [2].

For nonwoven manufacture, the practical levers are thickness, compaction, and fibre blending. Blended natural-fibre needle-punched mats outperformed mono-fibre mats, and higher hemp proportion and greater thickness raised absorption [5]; compact kapok structures with low air permeability performed best among a broad fibre set [10]. These findings support specifying thicker, well-compacted nonwovens with controlled permeability, while recognising that the relative contribution of each variable is not independently established.

For woven manufacture, the evidence cautions against assuming that heavier or thicker fabrics automatically absorb more. Li et al. found no significant correlation with thickness, surface density, or porosity [1], while Samuel et al. found yarn type and weave to matter, with textured polyester yarns performing better [7]. A defensible strategy is to control yarn structure and inter-yarn pore geometry explicitly, and to test at the incidence angles expected in service, since incidence angle affected measured absorption [7]. Where composites are involved, resin infusion should be expected to reduce absorption [9], so open-porosity retention becomes a design constraint.

Finally, additive routes such as microcapsule doping [2] and perforated foam-fabric hybrids [4] offer tuning options but introduce dependence on concentration, perforation rate, aperture size, and backing. They are best treated as application-specific modifications requiring empirical validation rather than as general-purpose improvements.

CONCLUSION

Conclusions

The supplied evidence supports a clear but conditional conclusion: textile sound absorption is governed by airflow resistance, pore architecture, thickness, and mounting, but the relative importance of these factors differs between nonwovens and wovens, and the woven evidence is internally contested. Nonwoven studies converge on thickness, compaction, permeability, and blending as practical levers [5][10]. Woven studies disagree, with one reporting no significant correlation between absorption and thickness, surface density, or porosity [1] and others finding that yarn type, weave, thread density, layer count, and incidence angle matter [3][6][7]. The strongest and most consistent gains come from hybrid and multilayer assemblies-woven facings on nonwoven cores, microfibre resistive layers, microcapsule doping, and perforated foam-fabric combinations-but these outcomes depend on backing, layer count, and test configuration [2][3][4][6][8]. Three-dimensional woven work adds that fibre type matters, with jute and flax outperforming glass, and that resin infusion suppresses absorption [9]. For applied design, the defensible position is to specify and validate assemblies under intended mounting conditions, to control air permeability and pore geometry rather than bulk density alone, and to treat additive or composite routes as application-specific. The field would benefit from studies that measure airflow resistance and pore-size distribution across woven and nonwoven families under matched conditions and frequency ranges, and from evidence on durability in service.

SCOPE

Limitations

This review is based solely on the ten supplied source records and their abstracts; full texts were not available, so methodological details, sample sizes, and statistical treatments could not be verified. Several sources are described only as 'Scholarly publication' without a named journal, and no DOI or reference list is provided. The studies use different measurement methods-impedance tube, anechoic chamber, and a purpose-built tester-and different frequency ranges and backing conditions, which limits direct comparison of absorption coefficients. Fibre types, manufacturing routes, and structural ranges vary widely, and no supplied study isolates airflow resistance from thickness or porosity experimentally. The apparent disagreement between Li et al. [1] and other woven studies [3][6][7] may reflect differences in experimental object, structural range, or mounting rather than a genuine mechanistic conflict, and the supplied evidence does not resolve this. No source addresses durability, cleaning, humidity, or long-term service performance. This article is an AI-assisted editorial review and has not been externally peer reviewed; it does not claim systematic-review methods, and no company or product is endorsed.

BIBLIOGRAPHY

References

1. Huiqin Li, Nan Zhang, Xiao-Dan Fan, Jixian Gong, et al.. (2020). Investigation of effective factors of woven structure fabrics for acoustic absorption. Scholarly publication.
2. R. Atienzar-Navarro, M. Bonet-Aracil, J. Gisbert-Paya, R. del Rey, et al.. (2020). Sound absorption of textile fabrics doped with microcapsules. Scholarly publication.
3. Pilar Segura-Alcaraz, Jorge Segura-Alcaraz, I. Montava, M. Bonet-Aracil. (2018). The Use of Fabrics to Improve the Acoustic Absorption: Influence of the Woven Fabric Thread Density Over a Nonwoven. *Autex Research Journal*.
4. R. Atienzar-Navarro, R. del Rey, J. Alba, V. Sanchez-Morcillo, et al.. (2020). Sound Absorption Properties of Perforated Recycled Polyurethane Foams Reinforced with Woven Fabric. *Polymers*.
5. S. Boominathan, M. Bhuvaneshwari, K. Sangeetha, K. M. Pachiyappan, et al.. (2022). Influence of Fiber Blending on Thermal and Acoustic Properties Nonwoven Material. *Journal of Natural Fibers*.
6. Pilar Segura-Alcaraz, Jorge Segura-Alcaraz, I. Montava, M. Bonet-Aracil. (2019). The effect of the combination of multiple woven fabric and nonwoven on acoustic absorption. *Journal of Industrial Textiles*.
7. B. T. Samuel, M. Barburski, J. Blaszcak, E. Witczak, et al.. (2021). The Influence of Yarn and Weave Structures on Acoustic Materials and the Effect of Different Acoustic Signal Incidence Angles on Woven Fabric Absorption Possibilities. *Materials*.
8. M. P. Segura Alcaraz, M. Bonet-Aracil, J. Segura Alcaraz, I. Montava Segui. (2017). Sound absorption of textile material using a microfibres resistive layer. Scholarly publication.
9. P. Paul, Meenakshi Ahirwar, B. Behera. (2023). Acoustic behavior of three-dimensional woven fabrics and their composites: role of fiber type and weave architecture. *Journal of the Textile Institute*.
10. Thirumurugan Velayutham, M. R. Kumar, Paramasivam Sundararajan, I. Chung, et al.. (2021). A Study on the Effect of Natural Regenerated and Synthetic Non-woven Fabric Properties on Acoustic Applications. *Journal of Natural Fibers*.