



Vanderbilt Chemicals, LLC

A Wholly Owned Subsidiary of R.T. Vanderbilt Holding Company, Inc.

VANOX[®] CDPA Solid

Antioxidant

**A high amine activity antioxidant
that maximizes heat resistance
in severe applications**

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Please visit our website for sample requests, sales specifications, and Material Safety Data Sheets.

www.vanderbiltchemicals.com

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"Certified Property" indicated a property certified on the product's Certificate of Analysis.

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VANOX[®] CDPA Solid Antioxidant

4,4'-Bis(alpha,alpha-dimethylbenzyl)diphenylamine

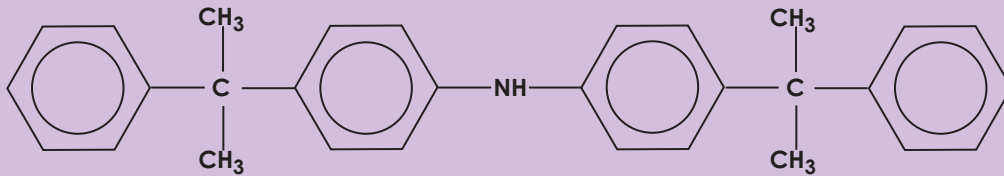
VANOX CDPA Solid is a low volatility, high amine activity antioxidant that is especially effective in HNBR and ACM rubbers for high temperature applications. In combination with the synergist antioxidant **VANOX ZMTI**, it provides maximum heat resistance to EPR, EPDM, IR, NBR, NR and SBR rubber compounds.

The following technical data demonstrate the equivalence of **VANOX CDPA Solid** and Naugard[®] 445.

CAS Number and Chemical Structure Analysis:

VANOX CDPA Solid and Naugard 445:

- CAS# 10081-67-1 (99%)
- Chemical Nomenclature: 4,4'-Bis(alpha,alpha-dimethylbenzyl)diphenylamine
- Melting Point: >98°C (>208.4°F)
- Chemical Structure:



As shown in Figure 1, the FTIR comparison indicates the equivalence of the essential major components. In Figure 2, the melting points of **VANOX CDPA Solid** and Naugard 445 are identical.

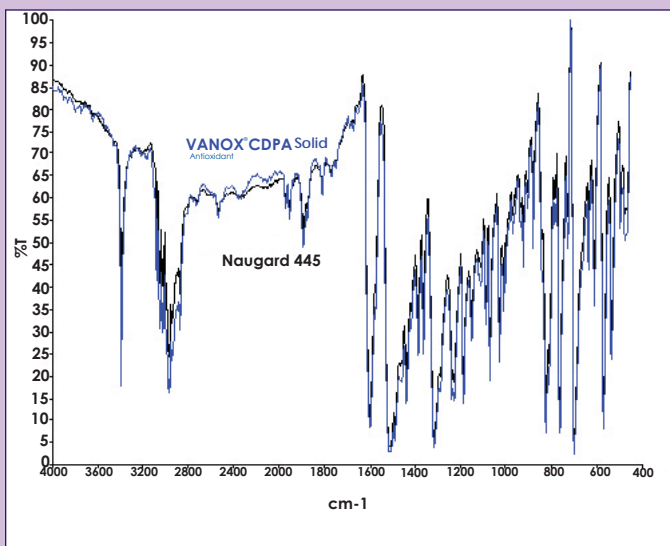


Figure 1: FTIR Comparison

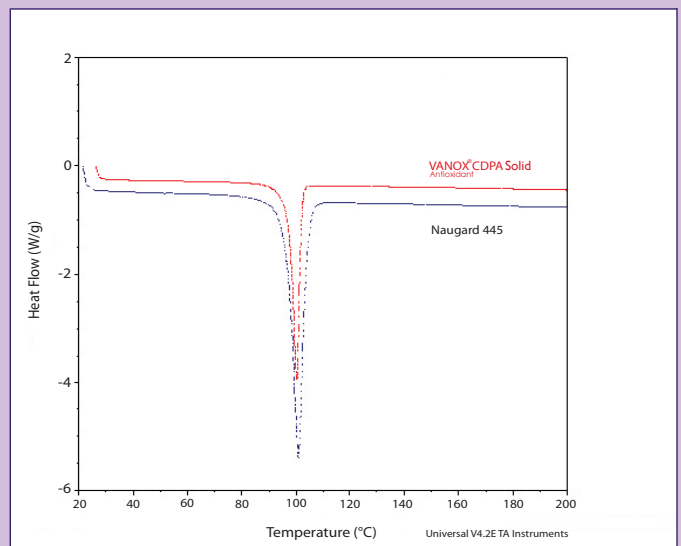


Figure 2: DSC Melting Point

VANOX[®] CDPA Solid Antioxidant vs. Naugard[®] 445 in HNBR

In order to further demonstrate the equivalent performance of **VANOX CDPA Solid** and Naugard 445, and to evaluate the effect of experimental error, Rubber Laboratory testing was run in duplicate.

Compounds	A1	A2	A3	A4
Zetpol [®] 2020 HNBR	100.0	100.0	100.0	100.0
Zinc Oxide	5.0	5.0	5.0	5.0
Stearic Acid	0.5	0.5	0.5	0.5
N330 Carbon Black	20.0	20.0	20.0	20.0
N990 Carbon Black	45.0	45.0	45.0	45.0
Naugard[®] 445	1.5	1.5	---	---
VANOX[®] CDPA Solid Antioxidant	---	---	1.5	1.5
VAROX[®] DCP-40KE Peroxide Accelerator	8.0	8.0	8.0	8.0
Totals	180.0	180.0	180.0	180.0

ASTM D1646, Mooney Viscosity @ 100°C (212°F), ML1+4

Viscosity, μ	87.2	84.7	85.1	86.2
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Mooney Scorch at 121°C (250°F)

Minimum Viscosity, μ	55.0	53.4	53.0	53.9
t ₅ , (min)	24.36	24.82	25.42	24.82

ASTM D5289, Moving Die Rheometer @ 171°C (340°F), 0.5° Arc

Minimum Torque, M _L , dN·m	1.33	1.31	1.37	1.34
Maximum Torque, M _H , dN·m	25.08	25.32	25.51	25.22
t ₅₁ , (min)	0.52	0.52	0.52	0.51
t'90, (min)	6.34	6.42	6.35	6.28
Cure Rate Index, (min ⁻¹)	17.2	16.9	17.2	17.3
Cure Rate, dN.m/(min)	4.08	4.07	4.14	4.14
Tan Delta at M _L	1.22	1.23	1.21	1.22
Tan Delta at M _H	0.06	0.06	0.06	0.06

A1	A2	A3	A4
Naugard® 445	Naugard 445	VANOX® CDPA Solid Antioxidant	VANOX CDPA Solid

ASTM D412, Method A, Die D, Stress Strain Tests @ 21°C (70°F)

(Cure test slabs t' 90 + 2 minutes at 171° C)

200% Modulus, MPa	14.84	16.11	15.93	16.22
Tensile, MPa	24.68	25.17	25.33	24.82
Elongation at Break, %	341	332	326	334

ASTM D2240, Shore A Durometer @ 21°C (70°F)

Hardness, Points	66.8	67.1	67.1	66.9
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ASTM D573, Rubber Deterioration, 70 hrs. @ 175°C (347°F)

Retained Tensile, %	59.5	67.0	54.9	67.4
Aged Tensile, MPa	14.69	16.86	13.90	16.73
Retained Elongation, %	24.3	26.2	22.7	26.0
Aged Elongation, %	83	87	74	87
Hardness, Pts. Change	+11.4	+12.0	+12.1	+11.6
Hardness, Aged Points	78.2	79.1	79.2	78.5

ASTM D573, Rubber Deterioration, 168 hrs. @ 150°C (302°F)

Retained Tensile, %	100.3	101.1	99.1	100.8
Aged Tensile, MPa	24.74	25.43	25.10	25.01
Retained Elongation, %	53.4	54.8	54.9	52.7
Aged Elongation, %	182	182	179	176
Hardness, Pts. Change	+10.0	+9.8	+9.7	+10.5
Hardness, Aged Points	76.8	76.9	76.8	77.4

ASTM D395, Method B – Compression Set, 70 Hours at 150°C (302°F)

(Cure Buttons at t' 90 + 12.5 minutes at 171° C)

Set, %	28.7	29.7	29.8	30.3
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VANOX[®] CDPA Solid Antioxidant in a Vamac[®] G compound

VANOX CDPA Solid is a high molecular weight diphenylamine antioxidant that has successfully replaced Naugard[®] 445 in natural rubber and most synthetic polymers and compounds. This cost-effective antioxidant was compared to Naugard 445 in a Vamac[®] G compound.

Vamac[®] (AEM) ethylene acrylic elastomers are used in applications where flexibility is needed in combination with both heat and oil resistance. Generally 2 phr of diphenylamine are recommended in black formulations. The results of the two compounds are compared below to demonstrate the equivalent performance of VANOX CDPA Solid and Naugard 445.

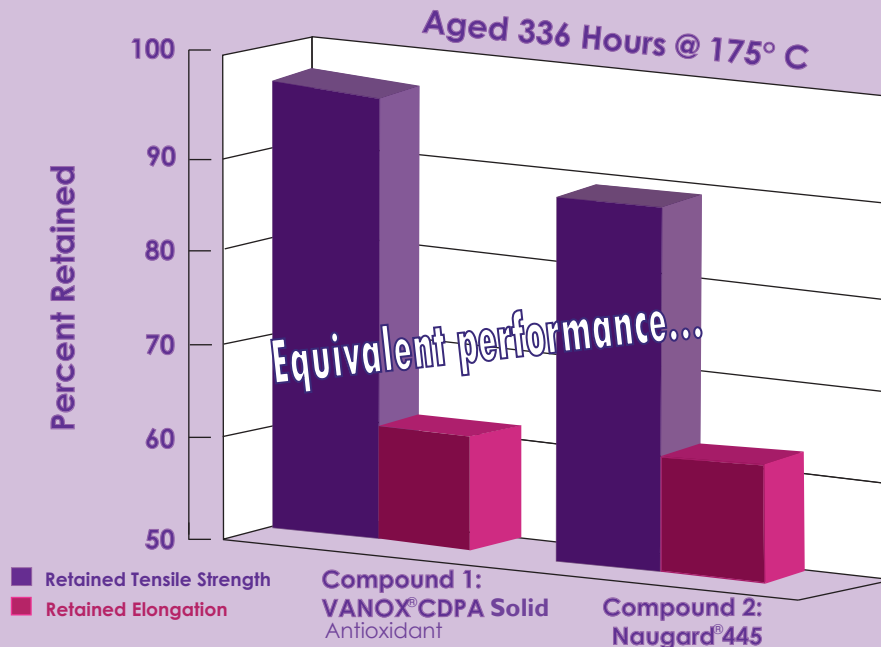


Figure 3: Retained Tensile Strength and Elongation

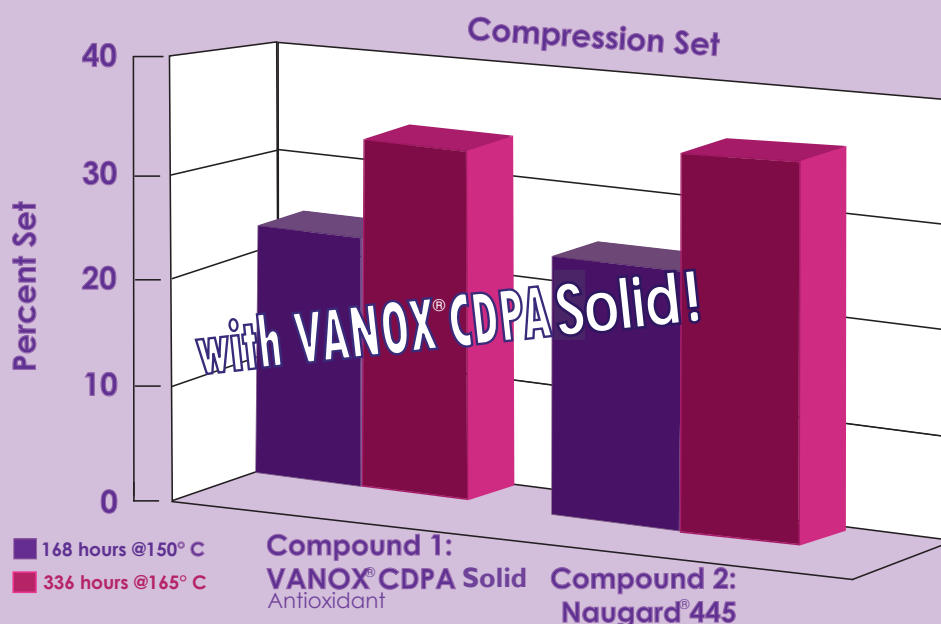


Figure 4: Compression Set Resistance

Ingredients	Compounds (phr)	
	1	2
Vamac® G ethylene/acrylic elastomer	100.0	100.0
N774 Carbon Black	65.0	65.0
Stearic Acid	1.5	1.5
VANFRE® VAM Processing Aid	1.0	1.0
Armeen® 18D	0.5	0.5
VANOX® CDPA Solid Antioxidant	2.0	---
Naugard® 445	---	2.0
VANAX® DOTG PWDR Accelerator	4.0	4.0
DIAK® No. 1 Curing Agent	1.5	1.5
Totals	175.5	175.5

PHYSICAL PROPERTIES

Press Cured 10 min. @ 177°C (350 °F) and Postcured 4 hrs. @ 175°C (347 °F)

100% Modulus, MPa	7.1	7.4
Tensile Strength, MPa	16.1	16.4
Elongation, %	280	259
Hardness, Shore A	70.4	70.9

OVEN AGED 336 HOURS @ 175°C (347°F)

Tensile Retained, %	96.1	89.0
Elongation Retained, %	62.9	62.5
Hardness, Shore A	+5.0	+5.2

COMPRESSION SET – METHOD B – PLIED – 168 HOURS @ 150°C (302°F)

Set, %	23.1	23.2
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COMPRESSION SET – METHOD B – PLIED – 336 HOURS @ 165°C (329°F)

Set, %	33.6	35.5
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MDR, ASTM D 5289 @ 177°C (350°F), 0.5°Arc

Minimum Torque, M_L , dN·m	0.33	0.28
Maximum Torque, M_H , dN·m	14.48	14.63
t_{s1} , (min)	0.81	0.82
t'_{90} , (min)	6.89	6.81

VANOX[®] CDPA Solid Antioxidant in an Vistalon[™] EPDM Compound Study

The selection of the correct antioxidant system that optimizes the physical properties of the finished product is extremely important in rubber compounding. This study compares the effectiveness of several antioxidants in peroxide cured EPDM. **VANOX ZMTI** has been shown to work synergistically with other antioxidants to greatly improve the retention of physical properties. **VANOX ZMTI** and **VANOX CDPA Solid** together provide the best overall results.

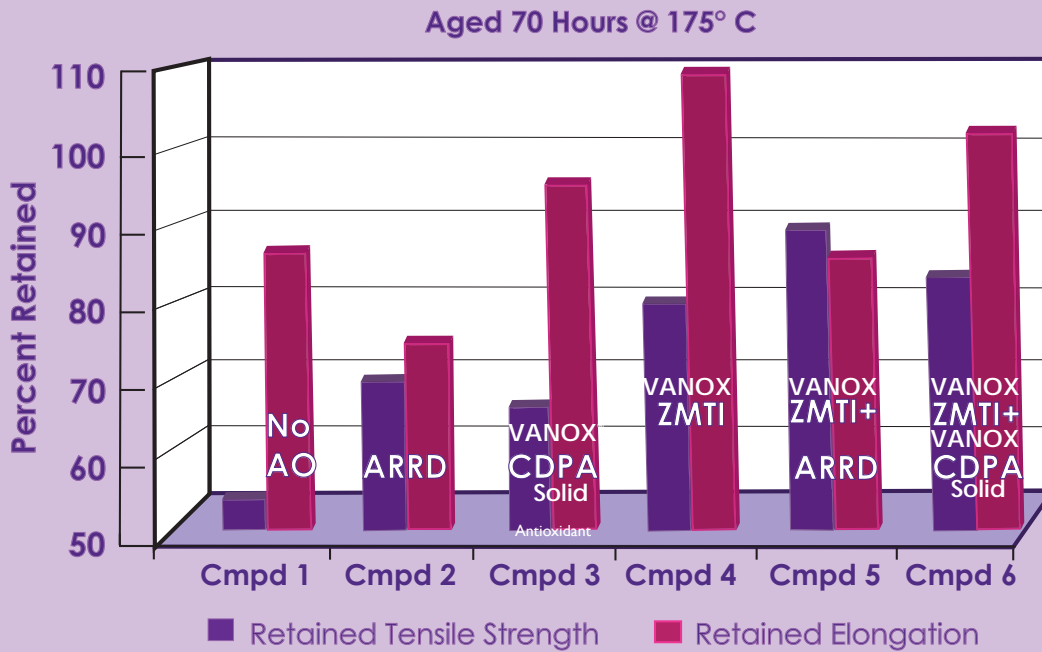


Figure 5: Retained Tensile Strength and Elongation

Ingredients	Compounds (phr)					
	1	2	3	4	5	6
	No AO	ARRD	VANOX CDPA	VANOX ZMTI	VANOX ZMTI + ARRD	VANOX ZMTI + CDPA
Vistalon [™] 706 EPDM rubber	70.0	70.0	70.0	70.0	70.0	70.0
Vistalon [™] 7500 EPDM rubber	30.0	30.0	30.0	30.0	30.0	30.0
N550 Carbon Black	110.0	110.0	110.0	110.0	110.0	110.0
Paraffinic Oil	45.0	45.0	45.0	45.0	45.0	45.0
VAROX[®] 802-40KE Peroxide Accelerator	6.0	6.0	6.0	6.0	6.0	6.0
VANAX[®] MBM PWDR Accelerator	1.0	1.0	1.0	1.0	1.0	1.0
VANOX[®] ZMTI Antioxidant	-	-	-	2.0	2.0	2.0
VANOX CDPA Solid Antioxidant	-	-	2.0	-	-	1.0
AGERITE[®] RESIN D[®] Antioxidant	-	2.0	-	-	1.0	-
Totals	263.0	264.0	264.0	264.0	265.0	265.0

Compounds					
1	2	3	4	5	6
No AO	ARRD	VANOX® CDPA Solid Antioxidant	VANOX ZMTI	VANOX ZMTI + ARRD	VANOX ZMTI + VANOX CDPA Solid

PHYSICAL PROPERTIES

Press Cured t' 90 + 2 min. @ 177°C (350°F)

100% Modulus, MPa	3.9	4.4	3.6	4.3	4.0	3.6
Tensile Strength, MPa	14.0	14.0	12.9	13.3	13.4	12.4
Elongation, %	287	304	306	272	302	283
Hardness, Shore A	67.8	69.4	65.0	70.3	68.7	67.8

OVEN AGED 70 HOURS @ 175°C (347°F)

Tensile Retained, %	53.0	67.8	62.6	78.4	88.3	81.9
Elongation Retained, %	84.7	72.0	93.5	108.8	85.4	101.1

OVEN AGED 168 HOURS @ 150°C (302°F)

Tensile Retained, %	73.4	83.0	77.9	96.6	96.2	92.6
Elongation Retained, %	91.3	79.6	96.4	110.7	98.3	107.4

COMPRESSION SET – METHOD B – 70 HOURS @ 150°C (302°F)

Set, %	30.4	26.1	32.3	27.2	31.2	32.1
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MDR, ASTM D 5289 @ 177°C (350°F), 0.5°Arc

Minimum Torque, M _L , dN·m	2.10	2.18	2.03	2.42	2.29	2.34
Maximum Torque, M _H , dN·m	16.95	16.82	14.89	17.63	17.18	16.72
t _{s1} , (min)	0.39	0.54	0.46	0.40	0.48	0.45
t'90, (min)	4.01	4.82	5.04	4.03	4.44	4.53

VANOX[®] ZMTI Antioxidant

Synergistic Antioxidant – To maximize a product's resistance to high temperature.

Rubber compounds are often protected by the use of just one antioxidant, but more severe service conditions require the use of combinations of antioxidants.

VANOX ZMTI is an antioxidant that is manufactured at **Vanderbilt Chemicals, LLC** in Murray, KY. It works particularly well in combination with other antioxidants. Its synergistic effect can be demonstrated in various rubber formulations based on polymers such as EPDM, Natural Rubber, Neoprene, NBR and SBR.

VANOX ZMTI provides excellent protection against heat and oxygen aging, especially when combined with amine or phenolic-type antioxidants, and is also beneficial where improved flex fatigue resistance is required. The synergistic effect of **VANOX ZMTI** with other antioxidants can be demonstrated in both mineral- and carbon black-filled compounds, as well as with conventional sulfur, low sulfur, sulfur-donors, or peroxide cure systems.

VAROX[®] Peroxide Accelerator cures provide vulcanizates with maximum thermal and oxidative stability, as well as superior resistance to compression set. Most antioxidants reduce peroxide efficiency, resulting in the loss of physical properties. **VANOX ZMTI** is fully compatible with peroxide cures and gives the best results in combination with amine antioxidants such as **AGERITE[®] SUPERFLEX[®] SOLID G** Antioxidant. This synergistic combination of antioxidants also offers the best thermal stability and maximum flex fatigue resistance in conventional sulfur cure systems.

AGERITE STALITE[®] S Antioxidant is the preferred antioxidant for Neoprene. When used with **VANOX ZMTI** in either a **VAROX** peroxide or an Ethylene Thiourea (ETU) cure system, the synergistic effect is evident in the increased state of cure and improved heat resistance.

This combination also improves flex-fatigue resistance despite providing higher modulus and hardness, along with improved compression set.

In summary, **VANOX ZMTI** exhibits the following features:

- Synergy with amines and phenol antioxidants
- Maximum high-temperature resistance
- Flex-fatigue resistance
- No interference with peroxide cures
- Nonvolatile
- Good color

VANOX[®] CDPA Solid Antioxidant Specifications

RTV Product Code: **54036**

Composition: 4,4'-Bis(α,α -dimethylbenzyl)diphenylamine

Physical State: White powder

	<u>Specification</u>	<u>Test Method</u>
*Ash Content	0.1% maximum	T-4
*Heat Loss 1 hr.at 70°C	0.3% maximum	T-1
*Melting Point, final	98°C minimum	AO-001

GENERAL INFORMATION

Typical values not routinely measured or reported on the Certificate of Analysis.

Density at 25°C	1.14 Mg/m ³
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* *Certified Property*

Uses - Antioxidant for NR and SR.

VANOX ZMTI Specifications

RTV Product Code: **53499**

Composition: Zinc 2-mercaptotolumidazole

Physical State: White to light tan powder

	<u>Specification</u>	<u>Test Method</u>
*Fineness, through 200 mesh	99.9% minimum	T-14D
*Heat Loss 2 hrs. @ 60-65°C	2.0% maximum	T-1A
*Zinc Content	17.2-19.3%	T-365, AA-103

GENERAL INFORMATION

Typical values not routinely measured or reported on the Certificate of Analysis.

Anti-Dusting Agent Content	3-5%
Density at 25°C	1.54 Mg/m ³
Melting Point, Initial	300°C minimum
Solubility - Soluble in ethanol and methanol.	Practically insoluble in other organic solvents and water.

* *Certified Property*

*Uses - A nondiscoloring, nonstaining antioxidant for NR and SR. Particularly effective in EPDM and Nitrile stock. Suggested as a synergist with **AGERITE[®] STALITE[®] S** Antioxidant, **AGERITE RESIN D[®]**, and **AGERITE SUPERFLEX[®] SOLID G** for aging at normal or elevated temperatures. Offers excellent flex resistance in NR, SBR, NBR, and CR when combined with **AGERITE SUPERFLEX SOLID G** and **AGERITE STALITE**.*



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