An Innovative Approach for Ensuring Effective Cleaning and Sanitizing of Multi-Use Synthetic Garments

By

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Driven primarily by economic factors, multiple use of synthetic protective apparel has increased dramatically in the food processing industry during the last decade. Questionable, however, is the ability of synthetic garments to be adequately cleaned and sanitized between uses by manual cleaning and sanitizing processes. The variables associated with all aspects of manual cleaning and sanitizing must be eliminated to provide a consistent and uniform process that is reliable and effective after each use. Process automation incorporating standard, documented cleaning and sanitizing conditions eliminates human factor variables and standardizes conditions for the process to be consistently effective and to meet HACCP regulatory requirements. Protective synthetic garments comprised of PolyConversions, Inc. VR™ were studied to determine if an automated laundering process could clean and sanitize without altering the surface properties of the VR™ material and without damaging the garment's structural integrity.

Introduction

As an alternate solution to manual cleaning and sanitizing processes, PolyConversions, Inc. has investigated the use of an automated laundering approach to eliminate the uncontrollable variables of manual cleaning by providing an automated uniform, rigorous approach to cleaning/sanitizing. Application of automated laundering to synthetic protective apparel must rely on laundering processes and equipment that have demonstrated reliability and effectiveness. However, these processes will also subject the synthetic garment to the numerous and repeated thermal, physical, and chemical factors that may impede the process' usefulness in its application. These factors include elevated wash/rinse water temperatures, chemical exposure (bleach, detergents, acids), washer and dryer turbulence, and elevated dryer temperatures.

PolyConversions, Inc. has developed VR™, a unique non-porous polyolefin laminate material, that meets the durability factors and cleanability factors required of a multi-use garment. This material has been used in the manufacture of aprons, gowns, sleeves, and other products to provide both employee safety and food product safety. Studies conducted previously have demonstrated that this material resists adhesion to oils, fats, greases, and meat/poultry residues and easily cleans with common detergent surfactants and low water temperatures. Additionally, VR™ gowns and aprons have enhanced cleanablility due to the absence of fasteners, grommets, and seams. This material is resistant to cold and remains stable to temperatures of 160^0F. VR™, unlike vinyl, contains no plasticizers and is not subjected to compositional change during typical meat/poultry processing conditions. These properties make VR™ garments a candidate for studies employing automated commercial laundering processes for cleaning and sanitizing.

Investigative Approach

Studies were conducted to ascertain the suitability of VR™ gowns and aprons for repeated automated washing and drying. VR™ garments with applied meat residue and microbial loads were subjected to equivalent washing and drying conditions. Upon completion of the washing cycle, the garments were assayed for microbial contamination. Electron microscopic examination was also conducted on the VR™ garments that had undergone repeated washing and drying cycles to determine if the automated commercial laundering process caused any microscopic degradation of the material or its surface properties.

The primary focus of this research was to determine the ability of a standard commercial laundering process to clean and sanitize gowns and aprons comprised of VR™ without compromising the integrity of the material and the garment. A commercial washer and dryer manufacturer, Alliance Laundry Systems (Ripon, Wisconsin), was selected to assist in this evaluation to determine:

- The ability of the gown or apron to withstand the chemical, physical, mechanical, and thermal stresses employed in the commercial washing and drying processes;
- The ability of the material to retain its original compositional integrity to maintain smoothness, non-porosity, flexibility, and tensile strength;
- The ability of the process to remove greases, oils, fats, and meat/poultry residues;
- The ability of the process to decontaminate the garments;
- The useful life of garments undergoing automated commercial laundering; and
- Operational logistics and costs for the commercial laundering process.

The effectiveness of both cleaning and sanitizing is a combination of both physical (mechanical) forces in combination with water, temperature, detergents and bleach to dislodge and inactivate microorganisms. To provide a basis for assurance that conditions were established to meet expected goals, key elements of the laundering process recommended by the Centers for Disease Control and Prevention (CDC) for clinical settings were used in the absence of any laundering guidance from the Food and Drug Administration (FDA) or US Department of Agriculture (USDA). VR™ garments were washed under these conditions and were subsequently subjected to visible inspection for removal of inoculated fats, oils, greases, and meat/poultry residues. Microbial sampling was conducted using 3M Petrifilm™ assays to ascertain the anti-microbial effectiveness of the process.

Synthetic garments selected for re-use should avoid materials that are negatively influenced by the conditions under which the garment may be used or laundered. As shown previously under electron microscopic analysis (see N. S. Slavik, "HACCP Considerations in Cleaning and Sanitizing Multi-Use Synthetic Garments", NationalProvisionerOnline.com, August 15, 2010), vinyl garments displayed extensive cracking, pitting, and flecking with multiple use. To determine if use and laundering conditions affected the VR™ garments, analysis by scanning electron microscopy (Imaging Technology Group of Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign) was performed to visually ascertain any microscopic surface changes over an expected lifetime of the re-used, multi-laundered garments.

Qualitative Observations

As a prelude to the electron microscopic and microbiological treatment efficacy studies of the laundering process, qualitative measures were first undertaken to determine if the VR™ garments could withstand the physical, chemical and temperature rigors of the laundering process. The introduction of detergents, acids, bases, and bleach in combination with turbulent washing, rinsing, and centrifugal action all could potentially contribute to gown or apron destruction. Water temperature and dryer temperatures also required evaluation to assure compatibility with temperature limitations of the VR™ material. Gowns and aprons were laundered and visibly inspected for cuts, tears, pulls, and deformations in garment shape, tensile strength, and flexibility.

An Alliance Laundry Systems UniMac UW60T3 washer was used to conduct these tests. The unit was operated at capacity accommodating 60 VR™ aprons, 50 VR™ gowns, or 150 VR™ sleeves per load. Capacity was determined by fill volume, not by weight. Typical operating conditions used for cotton linens were employed (two wash cycles at 140^0F for three minutes and six minutes, respectively, followed by two, two-minute rinse cycles) using pre-set deliveries of a high alkaline detergent, bleach, and an alkaline neutralizer (fluorosilicic acid as "sour"). Final bleach concentration was 50 ppm. These conditions meet the criteria established by the CDC for clinical settings as recommended in its "Guidelines for Environmental Infection Control in Health-Care Facilities" (2003).

These initial studies indicated that the VR™ garments could withstand the turbulent process and not suffer any visible deformation such as tearing, stretching, or knotting. The gowns and aprons were easily separated from each other after washing. No deleterious effects were similarly seen from chemical exposure, most notably from the alkaline detergent (pH 13.3) utilized in this process. The only visible effect on the VR™ material was a slight dulling of the surface luster or sheen of the material. See Plate I.

Preliminary studies on the ability of the laundering process indicated that the process could remove meat or poultry residues, greases, fats, and oils successfully. Uncooked pork sausage was smeared on various marked sections (8" x 5") of the VR™ garments to serve as a microbial challenge to the process. No visible indication of these residues could be seen or felt on these areas nor was any microbial growth detected subsequently via analytical evaluation using 3M Petrifilm™ plating.

A study was also conducted on garments obtained directly from a large poultry processing plant prior to garment cleaning. This evaluation had two objectives: One, to determine if the amounts of poultry residues and greases retained on actual-use garments could be successfully removed and two, to ensure that the resulting poultry residues did not interfere with the washing process or the equipment. The results of this apron study demonstrated that the garment surfaces could be cleaned and sanitized by the automated washing process as evidenced by 3M Petrifilm™ plating analysis. The amount of residues released to the washer in a full load (60 aprons) did not clog or built up in the washer chamber as evidenced by a clean washer chamber upon completion of the washing process.

Analytical Observations-Electron Microscopy

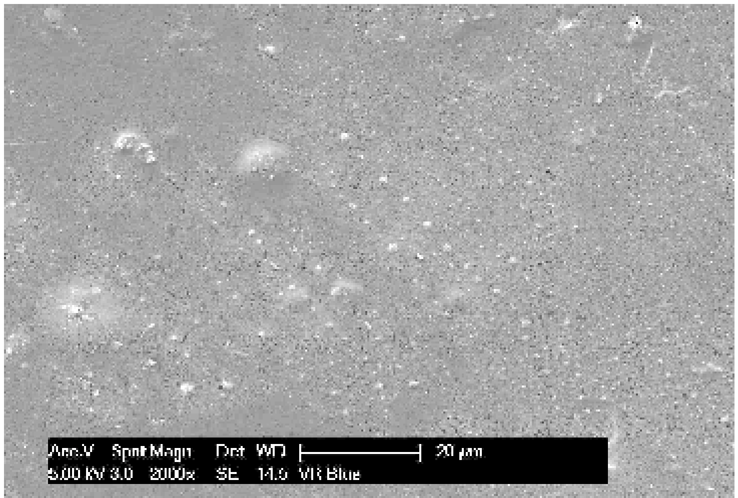
The conditions under which a garment is used, cleaned, and sanitized contribute to multi-use synthetic garment "material fatigue." These combined conditions subject the garment to physical, chemical and thermal stresses, which over time can have a deleterious effect on material surface composition. Changes in surface composition can contribute to flecking, cracking, and pitting of the garment's material and can lead to physical and microbiological contamination of the food product. VR™ aprons were evaluated by electron microscopy for surface changes after one month of in-house poultry plant use (20 days use/garment; subjected to manual cleaning with a granulated cleanser, surfactants, and sanitizers). In a separate study VR™ aprons were subjected to a series of multiple washes and dryings and evaluated similarly.

As seen in Plate I, a comparison is shown of an un-used VR™ apron (left) to a VR™ apron used for twenty days (right). Other than a dulling of the original surface sheen and wrinkling, the used VR™ apron retains its constructional integrity after the twenty days of use and manual cleaning.

Plate I
Comparison of VR™ Aprons, Un-Used and Used

Scanning electron microscopy (Phillips/FEI SEM XL30 ESEM-FEG) was employed to view the material at 2000 magnification to detect changes that might occur to the used VR™ material as a result of its extensive use. The result of this analysis is seen in Plate II comparing the surface of an unused VR™ apron with that of a VR™ apron used for 20 days with manual cleaning.

Plate II
Electron Microscopic Analysis of Un-Used and Used VR™ Aprons



Un-Used VR™ at 2,000X Magnification

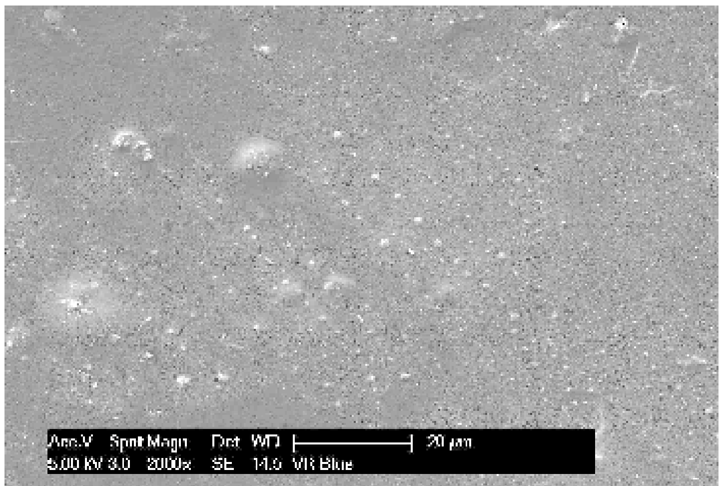
20 X Used VR™ at 2,000X Magnification

As seen in the photographs, the surface structural composition of the multi-used VR™ apron remains similar to the un-used apron. No cracks, fissures, pitting, or flecking are seen in the used VR™ material with only surface dust being visible in the photograph which would be expected. The used VR™ material retains its structural integrity after extensive use.

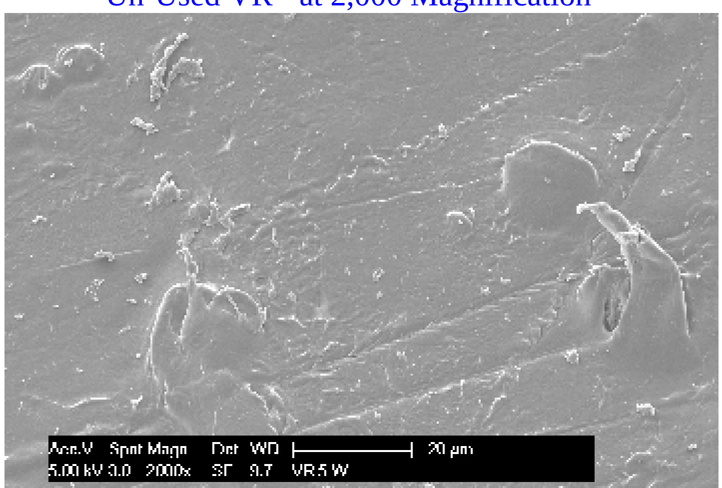
Similarly, application of the laundering process for use in a meat/poultry processing facility will require that the laundering process not interfere with the structural integrity of VR™ material over numerous washing and drying cycles. Electron microscopy was employed to view the material at 2000 magnification to detect microscopic surface changes that might occur to the VR™ material for up to fifteen washings under the laundering conditions employed during the qualitative studies (see above).

An electron microscopic comparative analysis of swatches of material from VR™ aprons that were unused, washed five times, washed 10 times, and washed 15 times demonstrated that the VR™ material did not succumb to any cracking, pitting, or flecking through fifteen washing cycles (see Plate III).

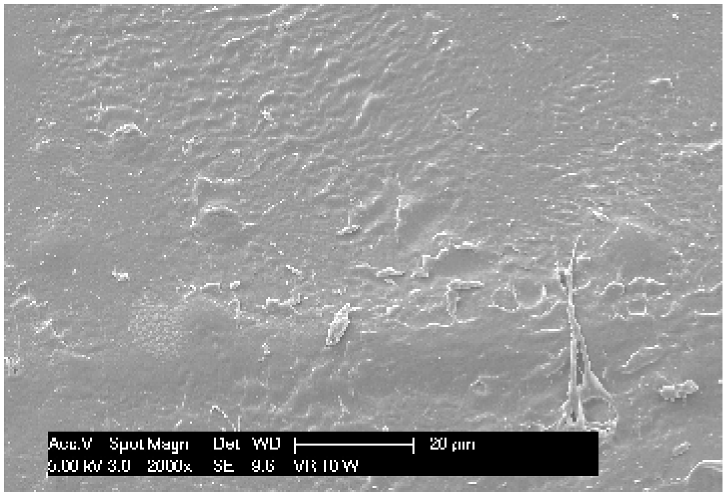
PLATE III
Comparison of VR™ Surface Structure of Unwashed and Washed Aprons



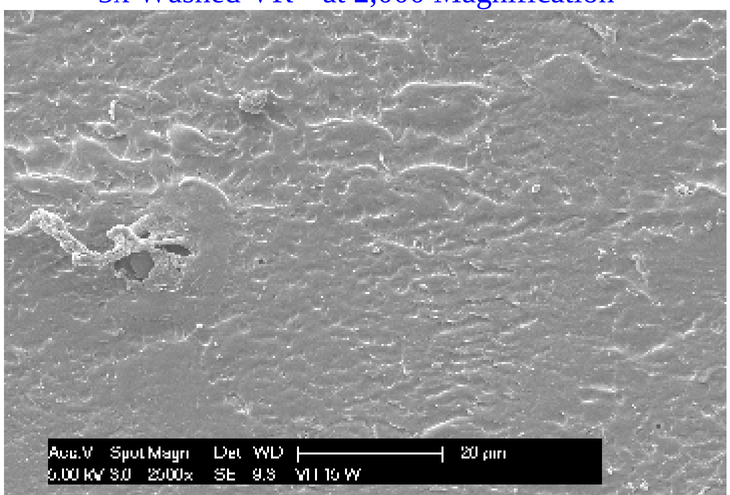
Un-Used VR™ at 2,000 Magnification



5x Washed VR™ at 2,000 Magnification



5x Washed VR™ at 2,000 Magnification



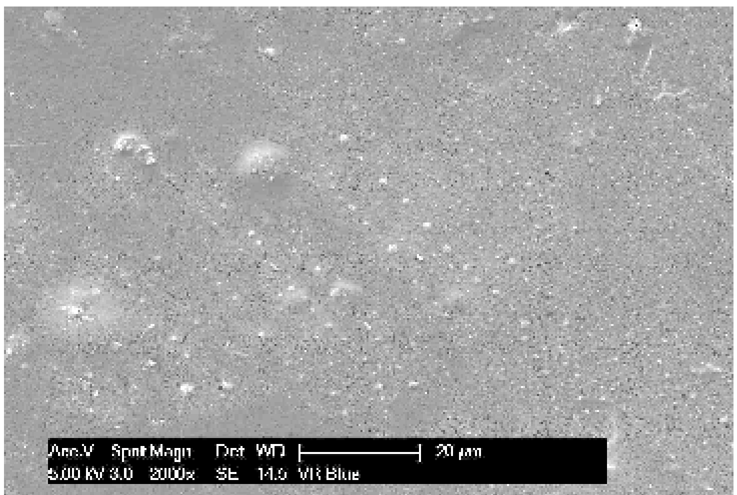
15x Washed VR™ at 2,500 Magnification

As seen in Plate III no discernible alterations could be detected in VR™ surface structure comparing unused VR™ with VR™ washed up to fifteen times, indicating that the material remains structurally unchanged when subjected to the heating and chemical stresses of the washing process.

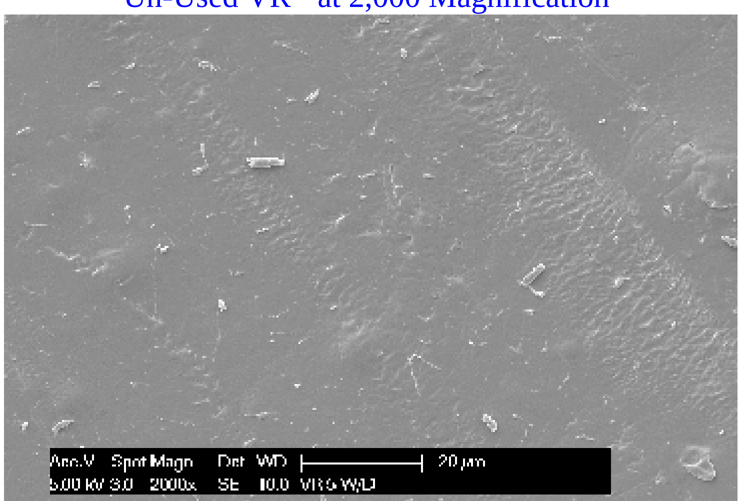
After washing the VR™ garments remained somewhat wet since the centrifugal process to eliminate excess water from the garments during the final stags of the washing process is not as efficient as it would be for porous cloth fiber materials. Although this excess water can be shaken off or allowed to dry by hanging over time, the use of a dryer was evaluated to determine if a dryer could also be a viable option for drying VR™ garments. It was known that VR™ like all polyolefin-based fabrics is heat sensitive at temperatures approaching 160^0F. However it was quickly determined that even at the lowest temperature setting, temperature fluctuations could not be adequately controlled by thermostatic controllers which resulted in noticeable material alterations from excessive temperature. As an alternative, ambient air was used to replace heated dryer air and coupled with tumbling, the garments were found to dry completely within a fifteen minute drying cycle.

To assure no changes in VR™ material structure resulted from the drying process, an electron microscopic examination was also conducted for combination washing/drying cycles. Since only unheated, ambient air could be used for VR™ material drying without any material alteration, an evaluation of only two drying cycles was conducted. No changes in surface structure were anticipated and none were observed as shown in Plate IV.

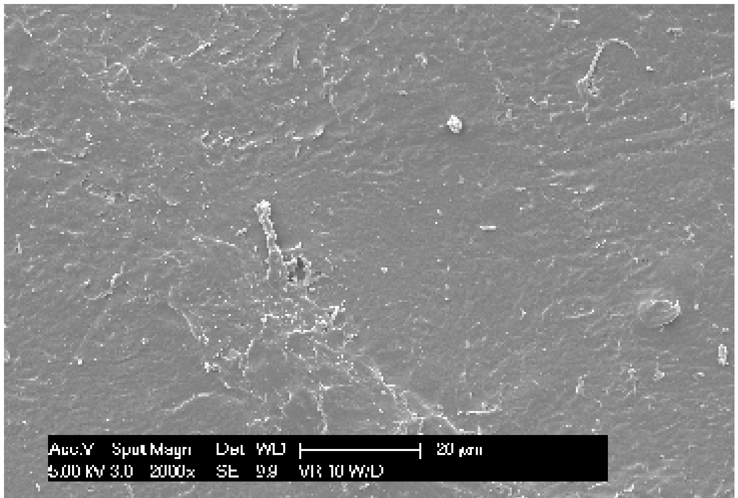
PLATE IV
Comparison of VR™ Surface Structure of Unwashed/Un-Dried and Washed/Dried VR™ Aprons



Un-Used VR™ at 2,000 Magnification



5x Washed, 1 Dry VR™ at 2,000 Magnification



10x Washed, 2 Dry VR™ at 2,000 Magnification

Analytical Observations-Microbial Treatment Efficacy

The ultimate goal of this evaluation was to determine that repeated washing and drying cycles did not interfere with the ability to clean and sanitize VR™ garments. Having established that the garments were not altered physically at macroscopic and microscopic levels, sanitizing efficacy of the laundering process was subsequently evaluated on garments that had been repeatedly laundered and dried. To marked areas (8" x 5") on previously laundered VR™ aprons (previously washed up to fifteen times), uncooked sausage was smeared and the aprons were again washed. The marked areas were swabbed using 3M Quick Swabs™, plated using 3M Petrifilm™, and subsequently analyzed for bacterial growth after 48 hours of incubation at 31^0C.

TABLE I
Bacterial Colony Forming Units (CFUs) Recovered

Number of Times Apron Previously Washed	Trial 1 CFU's/Plate	Trial 2 CFU's/Plate
0	0	0
5	0	0
10	1	0
15	0	0

The results in Table I demonstrate that the laundering process does not alter the cleaning and sanitizing characteristics of the VR™ material for at least fifteen wash cycles. These results confirm the electron microscopy findings that the surface of the material is not altered to affect cleaning and sanitizing.

The Automated Laundering Program

The results of this investigation clearly demonstrate that an automated laundering program can provide the poultry and meat processing industry with a process that can assure consistent and quality performance in cleaning and sanitizing limited-use garments. However the foundation of this program is the ability of the garment's material to retain its structural integrity and surface composition during use and during the washing/drying process. It has been shown that garments made with VR™ material provide such integrity, whereas those constructed of vinyl do not. VR™ garments do not become brittle and crack or fleck during repeated use. Additionally these garments have been demonstrated to endure the physical and chemical stresses from the laundering and drying processes used in this study to provide superior cleaning and sanitizing.

The program is built on CDC recommendations for laundered linens used in clinical hospital environments. Holding to a higher level of standard can assure that processed multi-used garments in the meat and poultry processing industry will be adequately cleaned and sanitized to eliminate disease-causing microbial agents. This study has demonstrated that the process is highly effective in removing meat and poultry residues, allowing the contaminated garments to be effectively sanitized. The washing process and drying process did not affect the structural integrity of the garment, its surface characteristics, or the ability of the garment to retain its cleanability characteristics over at least 15 washings.

The ultimate goal of implementing this program is to assure that all limited-use garments are subjected to a rigorous, standardized cleaning and sanitizing process that provides consistent and proven performance not influenced by individual employee behavior factors. However, implementing an automated laundering process in a meat or poultry processing facility requires economic justification to determine cost effectiveness. Factors involved for consideration include equipment costs, operational logistics, required space, utility costs, supply costs, and labor cost redistribution (shifting from the individual employee to centralized on-site laundering). This will be the topic of discussion in the third part of this series.

About the Author
Nelson S. Slavik holds a Ph.D. in microbiology from the University of Illinois at Urbana-Champaign (1975) and has previously served on the University of Illinois faculty within the Department of Health and Safety Studies. He is president of Environmental Health Management Systems, Inc. (Niles, Michigan) and consults with the healthcare industry regarding environmental and health and safety regulations, microbial decontamination, hazardous waste management, and hazardous materials management. He currently serves as a regulatory and technical consultant to PolyConversions, Inc. and consults with the food industry on microbiological safety issues and the efficacy of germicidal treatment of reusable and disposal products.

About PolyConversions, Inc.

PolyConversions, Inc. (www.PolyCoUSA.com) was founded in 1993 to research and develop exclusive splash and aerosol protective materials and apparel designs for industrial applications. Manufacturing strictly in the US, PolyConversions produces under the trademark VR™ Protective Wear designed as a cost effective durable replacement for vinyl and other traditional protective apparel impervious materials.

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