TUBULAR TIRES: ADHESIVES AND PRACTICE

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Introduction

Historically, tubular tires, 'sew-ups', have been the tire of choice for competitive cycling. While the modern clincher tire-rim combination can compete with the pressures, rolling resistance's, handling and ease of repair with the tubular, the tubular tire-rim combination will always be lighter than the clincher tire-rim combination. With the lightest clincher rim being easily 100 grams heavier than the lightest tubular and with most clincher tire/tube combinations heavier than tubulars, the lightness of the tubular tire-rim leads to less resistance to acceleration and braking -- the 'jump' to which tubular aficionados refer -- as well as making the total weight of the bicycle less. An additional advantage is that the tubular tire design is very resistant to 'rim-pinch' (snakebite) type flats. As the clincher tire developments have advanced, tubulars have become less popular -- largely because of the perceived difficulties in mounting and the difficulties in repairing flats.

We believe that the significant advantages of rim-tire weight will continue to make tubular tires attractive to cyclists and, consequently, their use will continue. The principal short-coming, then, is the proper mounting of tubulars to minimize the probability that they will 'roll-off' the rim -- usually at inopportune times such as high-speed descents, corners or banks. The mounting of tubular tires is critical to the rider's safety. The adhesive bond between the rim and tire must resist lateral loads that result from cornering, banking or catching a pedal in a corner and skidding.

Despite the best of efforts, a well-glued tubular may still roll. However, there are steps that a rider can take to minimize that chance by using the proper adhesives and the proper application procedure. In this article, we discuss the results of our experience in the laboratory and on the road.

Adhesive Performance

There are four principal defenses against roll-off: 1) rim shape; 2) tire stretch; 3) air pressure; and, 4) adhesive bond between tire and rim. The rim shape is dictated by the manufacturer. The resistance resulting from the tire stretch is dictated by the shape and construction of the tire. The rider has control only over the air pressure and the adhesive bond. *The most important factor accounting for over 60% of the resistance to roll-off for a given rim is the adhesive bond.* Therefore, it is extremely important that the rider applies the adhesive properly to reduce the chance for catastrophic failure and resultant injury.

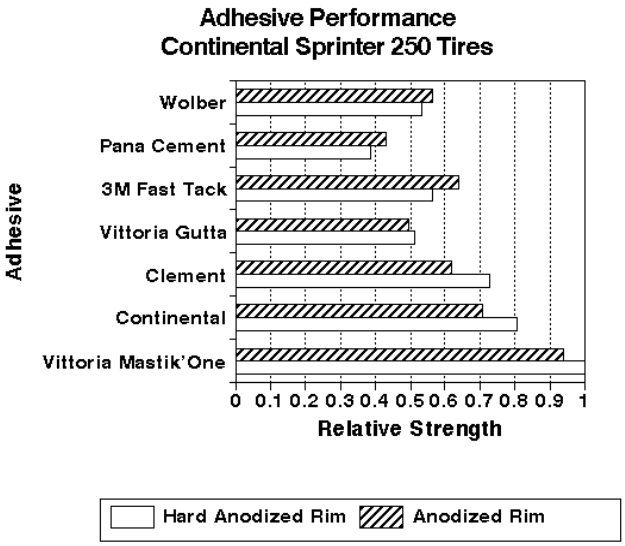
A well-designed adhesive bond is such that if failure occurs, it occurs in the adhesive -- not in the bond to the substrates, i.e. rim or tire. In our application, the tubular tire adhesive is expected to bond to metal or carbon fiber (we know, wood, too) and to the base tape of the tire -- two markedly different surfaces -- without attacking the base tape adhesive. The effective bonding to these two surfaces requires proper application and curing. Avoiding attack to the base tape is best accomplished by using adhesives designed for tubular tire applications.

The rider selects a rim type, tire type, adhesive type, application procedure and curing times. Any combination will perform differently with a change in one of the selections. In addition, the adhesive bond is expected to perform in extreme cold, heat and moisture. It is likely that most riders make choices which result in less than an optimal adhesive bond.

We are measuring adhesive performance, testing the variables which affect the strength of the bond. The results reported are based on a static measurement procedure developed to isolate those variables which affect the adhesive performance. *These should be indicative of relative performance in actual dynamic use. However, riders are encouraged to temper these results with their own experience since laboratory conditions cannot exactly reproduce riding effectiveness.*

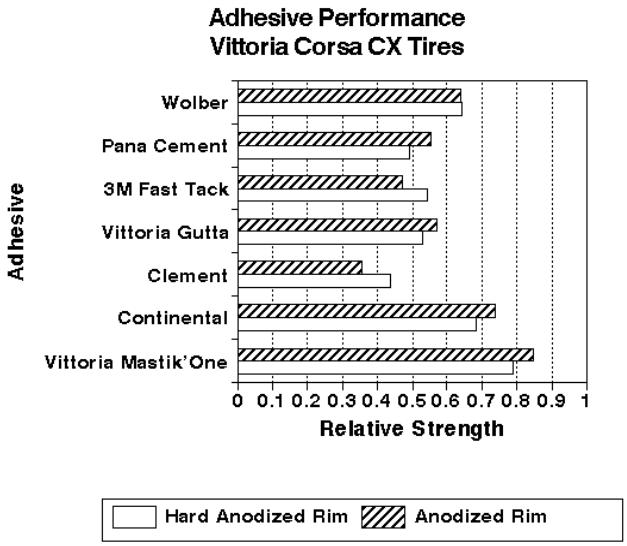
Seven adhesives, three rim types and three tire types have been extensively tested in the laboratory. The effects of application procedure including placement and number of adhesive coats and curing times, operating temperatures and operating moisture conditions have been tested. A subset of the results are presented in this article.

The first figure gives the relative strength of the adhesive bond for the seven glues, aluminum rims (both anodization types) and Continental tires. The results are presented as a relative strength normalized to the performance of Continental tires with Vittoria Mastik'One adhesive on hard anodized rims. This combination gave the best results of all combinations.



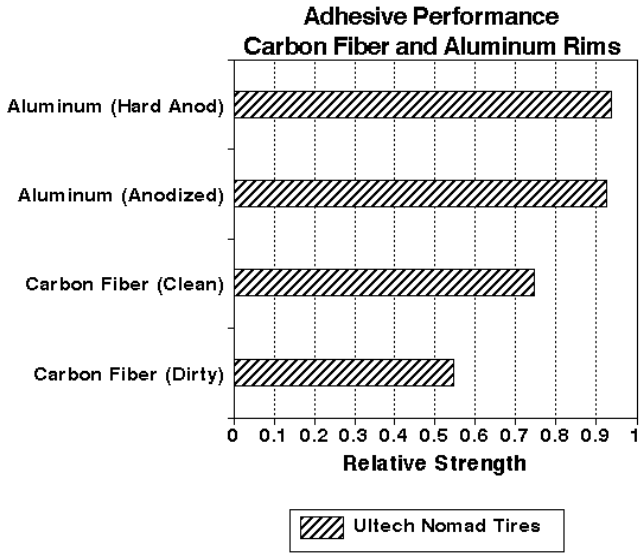
The results show the marked difference among the adhesives. The two 'white' glues perform better than the 'red' ones. They also perform better than 3M Fast Tack. This latter glue is not designed for tubular applications but is, nevertheless, widely used. These results are statistically significant. The rim-type has less of an impact.

Another high quality tire is Vittoria Corsa CX. The results from this study are given below.



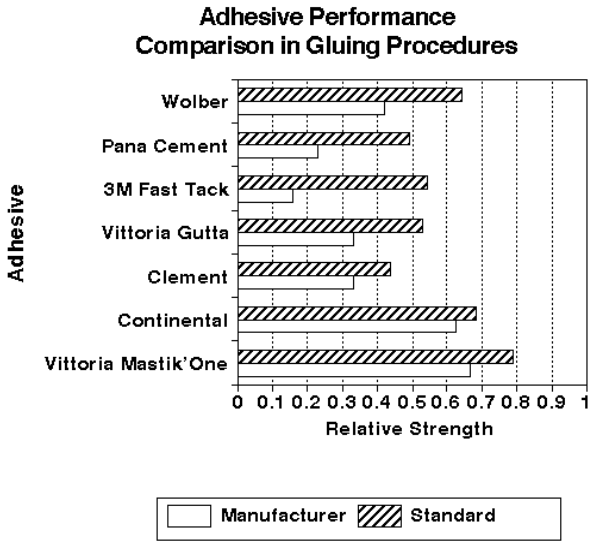
The results show that adhesive bond to this tire is substantially different than that to the Continentals for some of the adhesives. Rim-type made little difference.

Many riders use composite wheels. An example is the Mavic 3G rim. Since adhesives are designed for bonding to metal, a rider should anticipate poorer performance when bonding to the composite material. This anticipation is confirmed with the following results.



The adhesive used is Vittoria Mastik'One. This was a used rim with unidentified glue on the surface, i.e. 'dirty'. In other tests with aluminum rims, applying a new tire to one having glue on the surface did not affect the bonding strength. We ran tests with the rim as delivered and after cleaning. We cleaned the glue from the rim using the standard procedure. The chemicals in the water-based paint remover attacked the surface of the rim resulting in a rougher surface and reduction in the gloss. While the strength of the bond is greater, we do not know whether the rim was weakened. *Riders are cautioned to avoid using solvents on the composite surfaces to remove old glue.* It is clear that the bonding to the composite rim is inferior to that to the aluminum rims.

Many gluing procedures have been published. Most of these are based on experience. An exception is the manufacturers' procedures which come with the adhesive. We compared their suggested procedures against the one recommended below. The results are:



For all adhesives, the recommended practice ('standard' in the key) given below is superior to that recommended by the manufacturers.

We have conducted other studies of other gluing procedures, thickness of the adhesive layers, and curing times. In all cases, the procedure given below resulted in the strongest adhesive bond. The reality is that using the procedure given below, taking into account the type of tire, rim and adhesive, translates into faster cornering speeds before roll-off, i.e. increased safety for the rider.

Tubular Tire Mounting

All tubulars should be glued properly, no matter the event. The surfaces of the tire and rim must be mated intimately with adhesive. Reducing the amount of adhesive such as the pattern used in the 'triathlete' gluing procedure substantially reduces the strength of the bond and increases the probability of roll-off. Insufficient aging before riding, unclean surfaces and type of adhesive all contribute the weakening the bond. Remember, a well-designed adhesive bond is designed to fail in the adhesive. Reducing tire-rim contact, reducing the coverage, reducing curing times, increasing the adhesive thickness etc. all lead to weaker joints -- placing the rider at risk.

Given below are the procedures that we recommend for mounting tubular tires. They require patience, a little skill, time and planning. *Do not expect to mount a tire and ride instantly!* If you are in a hurry, buy and use clinchers.

We strongly recommend that you use only adhesives designed specifically for tubular tire installation. Using other adhesives could result in weak joints -- resulting in roll-off at inopportune times! *Adhesives not designed for tubular tire installation may dissolve the adhesive holding the base tape to the casing. This will result in a catastrophic failure.*

MOUNTING TUBULARS TO NEW RIMS

1. Test mount the tubular to a dry rim, inflate to a minimum of 100 psi and allow to sit overnight.

This stretches the tire which will make mounting easier. Also, by mounting and pre-inflating, you can check for tube and tire defects. We recommend that the tire is stretched on the rim for 24 hours at 100 psi. Once the tire is stretched, it is deflated and removed from the rim. You may find that a new tire will not mount easily on a rim. In this case, it must be pre-stretched by placing the tire over your shoulder, bandoleer-style, placing a knee in the tire and stretching. (Be careful!) This should provide sufficient stretch to place the tire on the rim.

2. Prepare the gluing surfaces.

Clean the rim surface with a solvent which does not leave a residue and does not attack the rim material. Examples are acetone, lacquer thinner and alcohol for aluminum. Manufacturers of composite rims should be contacted for recommend solvents. Do not use a solvent that leaves an oily film. Examples are mineral spirits or Stoddard solvent. These films reduce the strength of the bond between the adhesive and rim surface. The adhesive bond between to the rim is not mechanical. Roughing or scoring the rim is not required and will not improve the bond.

The tire should be inflated so that the base tape (inner surface) rolls outward. The base tape should be lightly scraped with a straightedge. If you see a change in the surface, you are removing excess latex. Some brands will show no difference.

3. Apply adhesive to the tire.

Whenever you work with harsh solvents such as those contained in the adhesives and in adhesive removers, wear painters' latex gloves to protect your skin and stay clean. We also recommend protective eye-wear to avoid eye-contamination.

Re-inflate the tire to the point that the base tape has rolled outward. Apply a layer of adhesive uniformly to the base tape using an acid or tooth brush. Ensure that the adhesive coverage is complete and uniform. If adhesive spreads to the side-walls of the tire, leave it alone: do not remove it as any solvent which could remove the adhesive will attack the adhesive holding the base tape to the tire casing. Allow the coat to completely dry -- we recommend 24 hours. Instructions

with the glues suggest that curing is faster but we have found that many glues do not come to full strength until six to eight hours have elapsed. High humidity conditions and/or low temperatures will lengthen the curing time beyond this.

We recommend that you glue a group of tires at one time. Those that will not be put into immediate use can be stored and you can anticipate that the adhesive bond will remain strong as long as the tire surface is kept clean.

4. Apply glue to the new rim.

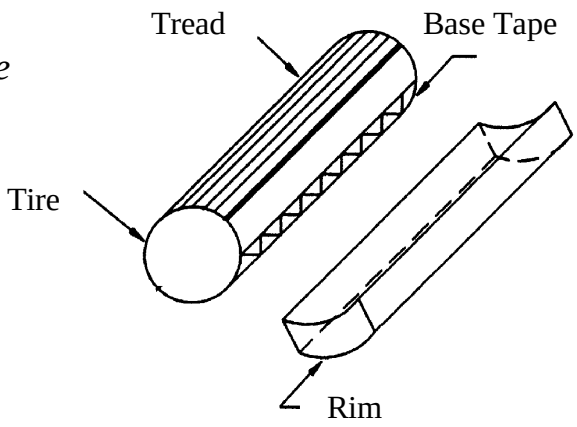
Multiple coats of adhesive, as described below, are used to build up the bed of contact with the tire. It is important to have sufficient adhesive to have intimate contact between the tire and rim. However, too much adhesive results in a weak joint which reduces the effectiveness of the adhesive. Applying one thick coat must be avoided.

Apply a thin layer of glue across the entire width of the rim gluing surface. The principal bond is at the edge; therefore, it is critical for best performance to ensure that the glue reaches the edges of the rim. A brush should be used to spread the glue. Do not be concerned if adhesive reaches the braking surface. This can be carefully removed later with a suitable solvent. This initial coat of glue should be allowed to dry -- preferably for 24 hours.

Apply an additional coat of adhesive and allow it to dry for at least 12 hours.

Apply a third coat. This is the mounting coat. Once this becomes ‘tacky’, the tire can be mounted.

One well-cured coat on the base tape.



Three coats on the rim.

5. Install the tire to the rim.

The tire should be partially deflated with enough air remaining so that the tire retains its shape. Place the rim vertically on a clean, smooth surface with the valve hole at the top of the rim. Place the valve stem through the hole and ensure that it is properly aligned -- straight through the hole. Grab the tire eight inches (8") away from the valve stem in both directions, pull outward with a mighty heave and place this section of the tire between your hands on the rim. Slide your hands another few inches down the tire, pull and install this section. Continue the process until all of the tire is mounted. If mounting becomes difficult 180^{o} from the valve stem, press the mounted portion of the tire against a table edge or other solid object to act as a 'holder', then roll the tubular onto the rim using both hands and thumbs on one side of the tire.

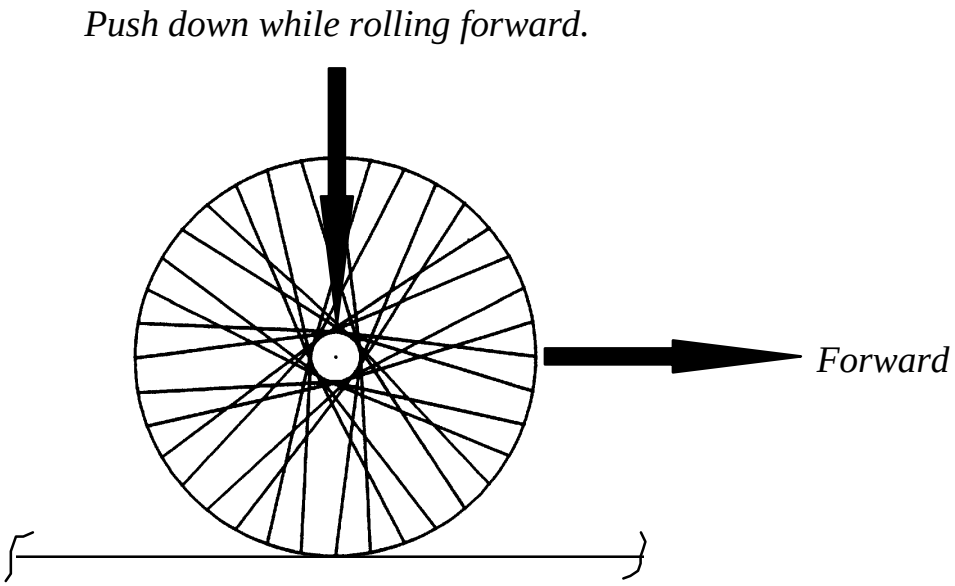
6. Align the tire on the rim.

With the tire fully on the rim, inflate slightly more (to 40-50 psi total, typically) giving the tire 'body' such that you will be able to lift it off the rim surface and replace it as you center the tire on the rim. Inspect the adhesive at the rim-tire interface. If it appears to be inadequate, remove tire from the rim and apply more glue to the rim.

Place the wheel in a truing stand or a frame and align the tire with the center of the rim. This is done by either lifting the tire and moving its center relative to the rim or twisting the tubular. You must work quickly at this stage because the glue will begin to set immediately. You can use the center tread or the base tape as an alignment gauge. Higher quality tubulars will align properly. Lower quality tires were not necessarily made straight, so perfect alignment may not be possible.

7. Seat the tire on the rim.

Remove the wheel from the stand or frame, place it on the floor and roll it while pushing downward on the hub. This presses the base tape against the rim. Inflate the tire fully, in excess of 100 psi, and check your alignment. If the alignment is not sufficient, deflate and return to step 6. Otherwise, store in a cool dry place fully inflated, preferably for 24 hours, to allow the adhesive to cure.



8. Clean the braking surface.

Clean the rim of glue using scrapers or solvents and rags. If you use a solvent, do not allow it to enter the interface between the tire and rim. The rim is clean if there is no 'squeal' when the brakes are applied (assuming well-adjusted brakes, of course.)

MOUNTING TUBULARS TO USED RIMS

Do not remove the old tubular until you are ready to begin the gluing process. The old tubular keeps the rim surface clear of debris which would weaken the new tire joint.

1. Remove the old tire from the rim.

If the adhesive joint is still strong, you will have to find a weak point in the joint. At that point, pull the tire away from the rim and insert a square-shafted screw driver. Rotate the screw driver around the rim progressively breaking the adhesive bond.

Scrap the edge of the rim with a copper scrub pad or knife to remove dirt. If the glue has become contaminated or if the rim has been subjected to multiple tire-mountings, the adhesive will have to be removed.

2. Remove the old adhesive from the rim.

This step is only required if the adhesive is contaminated or old, if there is too much adhesive on the rim or if the remaining adhesive covers the rim only in spots.

Use heavy duty furniture stripper to remove the adhesive. Follow manufacturer's precautions when using this toxic material. A water based, less hazardous paint stripper will work but this may require 10-12 hours to work per application.

Once the adhesive is removed, the rim should be cleaned with soap and water and an aluminum rim wiped with acetone.

At this point, the procedure for a new rim should be followed -- go to step 3 above.

3. Apply adhesive to the tire.

Follow the procedure outlined in step 3 above for a new tire. If you are installing a used tire, scrap the base tape. Apply a new layer of glue only if the old glue was removed during scraping or if the base tape does not appear to have a layer. The procedure for application is step 3 above.

4. Apply adhesive to the rim.

Apply at least one thin coat of glue to the rim. There may be places where the rim is bare. At those places, the adhesive needs to be built up to the surrounding thickness otherwise the bond will not be as strong as possible.

5. Mount the tire to the rim following the procedure beginning with step 5 above.

Inspection

Inspecting a mounted tubular can be tricky. It is impossible to inspect fully the mounting of a tubular without its removal -- which, of course, breaks the bond that you want to inspect. Do not deflate the tire to inspect. Look for signs of adhesive at the tire - rim interface. Roll the tire back. It should look firmly affixed to the rim. If you hear cracking and popping, the glue has become old and has hardened, making the bond weak and suspect.

There are no cycling industry or manufacturer's standards for a properly bonded tubular tire.

Conclusions

Tubular tires have advantages over clinchers largely due to the lightness of the rim and the resistance to pinch flats. Their principal disadvantage is that they can roll-off of the rim with potential resultant injury to the rider. The adhesive bonding the tire to the rim is the principal defense against roll-off, accounting for in excess of 60% of the load. This resistance to roll-off can only be obtained with proper application of an adhesive designed for tubular tire applications. Once properly mounted, the tire

will provide excellent service life with little chance for roll-off. Consequently, with proper selections, care and patience, all of the advantages of tubular tires can be attained with little chance of roll-off.

Readers with extensive experience have additional observations on adhesive performance. These observations should be included along with our recommendations to ensure optimal tubular tire performance.

Acknowledgments

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Citations

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