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[54] **STRINGED INSTRUMENTS WITH IMPROVED STRINGS DUE TO IRRADIATION AND PROCESS FOR PRODUCING THE SAME**

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[58] **Field of Search** ..... 204/159.15, 159.19; 84/199, 297 S

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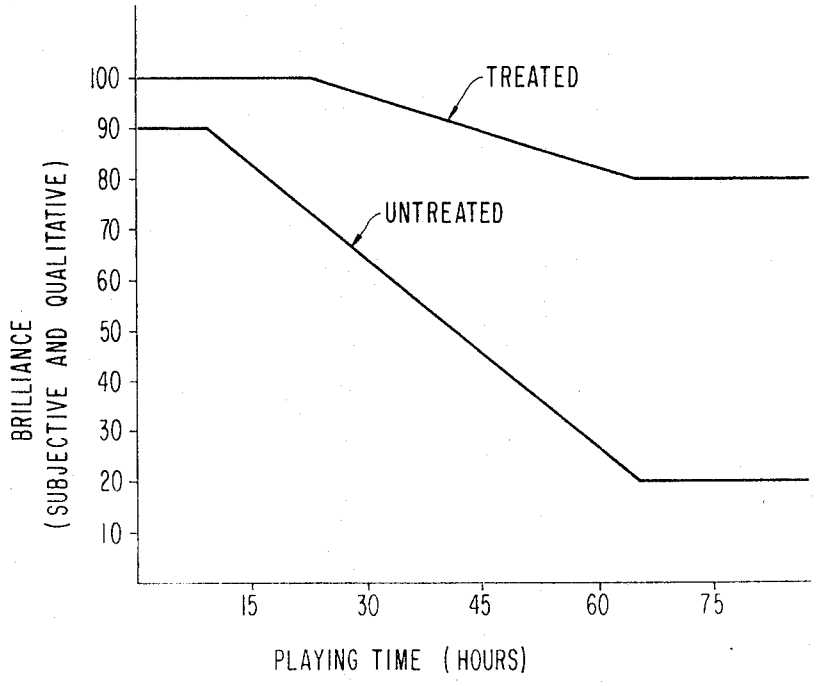
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[57] **ABSTRACT**

By irradiating nylon strings used for stringed musical instruments, longer life and improved musical properties are obtained. The strings thus irradiated can be used for a variety of stringed musical instruments.

14 Claims, 1 Drawing Figure

SUMMARY OF INDEPENDENT
IMPRESSIONS OF GUITARISTS



STRINGED INSTRUMENTS WITH IMPROVED STRINGS DUE TO IRRADIATION AND PROCESS FOR PRODUCING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to improved strings used for stringed musical instruments and to a process for improving the same.

2. Description of the Prior Art

It is known among players of stringed musical instruments that with increased playing time a loss of tonal qualities is encountered. This loss of tonal qualities has been attributed to the moisture, oil and/or dirt absorbed by the strings from the hands or the atmosphere. It is known that a partial restoration of the desirable tonal qualities can be obtained by wiping the strings with a cloth moistened with acetone, alcohol or similar hydrophilic organic solvents. However, the partial restoration of the desirable tonal qualities is quite temporary, and can only be achieved relatively few times before the strings must be replaced. The prior art has advanced no sound technical reason for the temporary partial restoration of the desirable tonal qualities by the use of such organic solvents.

The major criticism of strings used for stringed musical instruments (hereafter, unless otherwise indicated, the term "strings" refers to strings utilized in stringed musical instruments) such as nylon strings is that they quickly lose their original brilliance of tone and gradually lose their tonal qualities, becoming "dead" after too short an interval of playing time.

Such strings are replaced when they begin to fret untrue and sound dull, which is generally long before such strings break. A simple means to determine if strings have lost their ability to fret true is to compare the harmonic sounds at the twelfth fret with the fretted sound at the same fret. After properly tuning the string in question, a finger is lightly placed on the string over the twelfth fret and the string is picked. The string is then depressed at the twelfth fret and again picked. If the two tones are not identical, the string should be replaced. Prior to our invention, no method has been found to make strings, e.g., nylon strings, fret true for long intervals of time.

SUMMARY OF THE INVENTION

By irradiating nylon strings for use in stringed musical instruments with high energy ionizing radiation, the desirable musical qualities of the strings can be retained for greatly extended periods of time.

By exposing such strings to high energy ionizing radiation in accordance with the present invention the rate of growth of microcracks, which we have observed to be associated with the loss of tonal qualities, is appreciably decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

The FIGURE is a plot of tonal qualities versus playing time (in hours) comparing irradiated musical strings formed in accordance with the present invention to control strings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Our invention consists of exposing a nylon string in

wound or unwound form to ionizing radiation such as gamma photons from cobalt 60 or high energy electrons. A dose is applied to the strings which is empirically determined to yield the optimum musical properties, generally such dose being between 0.01 and about 100 megarads, more preferably between 0.15 and 15 megarads. By following the teachings of our invention we can increase the length of time that strings can be played before they no longer fret true.

In one series of experiments, we took a series of nylon polymer strings and exposed the strings to ionizing radiation. A control group of strings was not irradiated. Absorbed doses of 0.15, 1.5, 5.0, 10.0, 15.0, 20.0, 35.0 and 50 Megarads were utilized. The sets of strings exposed to total doses of 35 and 50 Megarads could not be tested for tonal qualities because the strings broke as the instrument was being tuned.

The strings exposed to total doses of 0.15 through 15 Megarads had both a more brilliant original tone and retained tonal brilliance longer than strings which had not been irradiated.

The unirradiated nylon strings, which had gone dead, were examined under a scanning electron microscope at magnifications up to 10,000 x. The area of the strings at the plucked area showed a few relatively deep gashes, presumably caused by a pick or the fingernails. The areas of the string at the frets showed many small microcracks and surface deformations or regions of high plastic flow. These microcracks and surface flaws visible in the scanning electron micrographs ran primarily at a shear angle of 45°. We have deduced that the mechanism for their formation probably resulted from a plastic deformation involving slippage of crystalline areas and creep related redistribution of polymer chains in crystallites through amorphous regions. We concluded, from our experimentation, that the ionizing radiation even at the lowest doses introduced some degree of crosslinking of the nylon polymer strings and, when this crosslinking occurred to a sufficient degree, perhaps to retard or prevent this molecular redistribution, the subjective tonal qualities, i.e., brilliance and like qualities, of the strings were improved, and these improved properties were retained for greatly extended periods of time.

We conducted further tests on nylon guitar strings. Sets of guitar strings were given a series of radiation dosages, and their tensile properties evaluated. Neither the strings exposed to 1.5 Megarads or the strings exposed to 0.15 Megarads showed any experimentally significant change in tensile properties relative to the unirradiated control, yet both sets of the irradiated strings exhibited superior tonal characteristics.

A series of guitar strings sets from several commercial producers were irradiated with dosages of 0.15 and 1.5 Megarads at dose rates of 1.2 megarads per hour in air. We did not irradiate a set of strings which served as controls. All strings were then played a given length of time, i.e., until the control strings went dead. Segments of the solid nylon monofilament strings from the fret areas and plucked areas were then examined at 500 x and 1,000 x to determine if microcracks were present. The control strings all showed microcracks with a 45° shear angle. Randomly oriented gouges due to user handling were ignored. In the control strings approximately 50 times as many cracks reflecting polymer chain migration establishing cleavage planes were present in the area of the frets as were present in the

plucked area, it being in the area of the frets where the moisture of the hands is present to serve as a plastisizer.

On the other hand, there were only a few microcracks present in the strings irradiated in accordance with the present invention, the number of microcracks generally being 5 percent or less as compared to the control strings.

One of the guitar players who played an average of 4 hours usually cleaned his strings when they started to change tone. He reported that the control strings always had part of the tonal qualities restored by cleaning with acetone. On the other hand, strings treated in accordance with our invention were not affected by acetone.

From this observation we concluded that the irradiation treatment of the present invention appreciably decreases the rate of formation of microcracks and may thereby decrease the rate of diffusion of water molecules into the string via the cracks. The importance of our discovery will be appreciated when it is realized the tonal quality in a stringed instrument is harmed by the following factors:

1. microcracks decrease the damping time (in a manner similar to vibrational decay that occurs in metal, due to intergranular cracks and dislocations.)
2. moisture and dirt in the region of the microcracks, which decrease the damping time;
3. the diffusion of water molecules into the strings, which speeds the formation of such microcracks.

All of the classicial guitar players involved in our testing programs said that the excellent, strong brilliance of tone obtained from strings treated in accordance with our irradiation treatment not only was initially more superior but lasted for from two to four times as long as the control strings. In the sets of strings given our irradiation treatment, the wire wound strings also lasted three to four times as long under playing conditions as the control strings before they went dead.

Although our current analysis of tonal quality is basically subjective, the results of many sample evaluations by several guitar players are provided in the attached drawing and comments wherein tonal quality is related to playing time in hours. As is easily recognized the prevalent observation is that strings irradiated in accordance with the radiation treatment of the present invention have demonstrably superior properties.

The present invention finds application with nylon strings such as nylon 6, nylon 66, and like materials, and can be of value when used for strings for any stringed instrument, e.g., violins, cellos, etc.

By the term "nylon" is meant generally a polyamide formed either by the reaction of a diamine with a dibasic acid or by the polymerization of an amino acid or its derivative. Thus, as an example, nylon 6/6 (polyhexamethyleneadipamide) is formed by reacting hexamethylenediamine with adipic acid. Similarly, nylon 6/10 and 6/12 are formed by the reaction of hexamethyenediamine with respectviely, sebacic acid and dodecanedioic acid.

While a preferred dose range has heretofore been set out, for different materials different total doses will be utilized. The most preferred dose will be determined empirically for any given set of strings, whether the strings be monofilament or wire wound. The dose rate is relatively non-critical, though it will be clear to one skilled in the art that for most practical commercial radiation sources the available dose rates will be in the range of from about 100 to about 10^{10}rads/hour. Values above and below this range can be used, of course, though at higher dose rates very expensive equipment is required and at lower dose rates an inordinant amount of time will be necessary. Accordingly, little would lead one skilled in the art to use such extreme dose rates.

In addition, different types of nylon strings will be sensitive to different radiation absorption such that while one type of strings may be unaffected by a low dose absorbed, or may be damaged by a high dose absorbed, another type would not. Generally, the absorbed dose will vary from about 0.01 to about 100 megarads.

While a few exemplary radiation sources have been listed above, it will be clear to one skilled in the art that any source of high energy ionizing radiation can be utilized to practice the process of this invention.

The following specific examples are offered to illustrate the practice of the present invention, but the present invention shall not be considered as limited thereby.

EXAMPLE 1

When Concertiste Extra Forte strings were exposed to gamma radiation from cobalt **60** at a dose rate of 1.2 megarads/hour for 7.5 minutes a dose of 0.15 megarads was received. The strings were installed on the guitar of a guitarist and played with the following results:

1. They required less frequent tuning initially.
2. They were unusually brilliant.
3. They were playable without loss of brilliance for 2 weeks, compared to 2 to 3 days with untreated strings.
4. After 21 days some decay in tonal qualities was observed, however they were still far more brilliant than the control after 1 week.
5. They were cut out of the instrument after 44 days at which stage they still had superior tonal quality compared to the untreated strings after 1 week of playing.
6. When examined under the scanning electron microscope no cracks were observed.

EXAMPLE 2

When LaBella "Golden Superior No. 900-B" strings were exposed to a radiation dose of 1.5 megarads their performance was reported by a guitarist to be substantially superior to untreated strings which after 1 week evidenced the same degree of tonal decay that treated strings showed after 22 days. The treated strings continued essentially at this level for an additional 21 days.

EXAMPLE 3

When Augustine strings were treated to 0.15 megarads and evaluated by a second guitarist, the results were again indicative of substantial improvement in tonal quality and life. After 39 days they were reported to have acceptable tonal qualities.

EXAMPLE 4

When the lower cost variety of LaBella ("the Concert 850-B") strings were irradiated to 0.15 megarads their brilliance initially was comparable to their top of the line product. Upon continued testing they too exhibited extended playing life.

EXAMPLE 5

Martin strings were irradiated to 0.15 megarads after which they were played. While the heavier 3 strings were not as brilliant as those of other brands tested they too were superior to untreated strings and had extended playable lifetimes. After approximately 1 week there was some loss of tonal properties. The three wire wound strings went dead during the third week while the higher tone strings (not wire wound) were judged "dead" after about 6 weeks.

EXAMPLE 6

When Concertiste Extra Forte strings were exposed to ionizing radiation to a dose of 1.5 megarads at a dose rate of 1.2 megarads/hour, their performance was at least equivalent to that of the 0.15 megarad treated string.

EXAMPLE 7

When Concertiste Extra Forte strings were irradiated to 0.15 megarads at a dose rate of 600,000 R/hour their performance was indistinguishable from those treated at 1.2 megarads/hour, lasting 58 days when the test was terminated without going dead.

EXAMPLE 8

When Concertiste Extra Forte strings were exposed to a 50 megarads dose, they broke while being installed on the test guitar.

EXAMPLE 9

Concertiste Golden or Mellow strings were exposed to 1.5 megarads at a dose rate of 1.2 megarads/hour, strung on the guitar, and played daily for 27 days before any decay was observed. The test was terminated after an additional 18 days at which time some further slight decay in tonal characteristics was observed.

EXAMPLE 10

LaBella "Golden Superior 900-B" strings were irradiated to 1.5 megarads, no tonal decay was observed after 24 days and the strings were not dead after a total of 67 days.

All of the strings used in the above examples are nylon strings but the specific chemical composition is unknown and unavailable.

An alternative embodiment of the present invention is to incorporate into the nylon strings a chemical compound or compounds which promote cross-linking upon irradiation. Such compounds are well known and include free-radical generating compounds such as benzoyl peroxide. These compounds may be added in an amount effective to promote cross-linking.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. A stringed musical instrument comprising

a support; and

nylon strings attached to said support, said strings exhibiting superior brilliance and true fretting for a long interval of playing time, said strings having been exposed to high intensity ionizing irradiation to achieve said superior brilliance and true fretting for long intervals of playing time, the total dose of absorbed radiation varying from about 0.01 to about 100 megarads.

2. The instrument of claim **1** wherein the treatment consists of exposing the strings to high intensity ionizing radiation.

3. The instrument of claim **1** wherein the radiation is gamma radiation from cobalt 60.

4. The instrument of claim **1** wherein the high intensity ionizing radiation is electron beam irradiation.

5. The instrument of claim **1** wherein the strings contain additives to promote crosslinking.

6. The instrument of claim **1** wherein the total dose absorbed by said strings varies from 0.15 to 15 megarads.

7. The instrument of claim **1** which is a guitar.

8. The instrument of claim **1** which is a violin.

9. The instrument of claim **1** which is a cello.

10. The instrument of claim **1** wherein said strings are wire wound strings.

11. The instrument of claim **1** wherein said strings are monofilament strings.

12. The instrument of claim **1** wherein said strings are exposed to high intensity ionizing radiation at a dose rate of from about 100 to about 10^{10} rads/hour.

13. The instrument of claim **1** wherein the total dose of high intensity ionizing radiation is applied at a dose rate in the range of from about 100 to about 10^{10} rads/hour.

14. The instrument of claim **7** wherein the high intensity ionizing radiation is applied at a dose rate in the range of from about 100 to about 10^{10} rads/hour.

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