

## Research Article

Xiaolong Sun, Yunchu Zhu, Jie Mao, Xiao Qin\*, Lijuan Li, Jiao Jin, and Huayang Yu

# UV aging behavior evolution characterization of HALS-modified asphalt based on micro-morphological features

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**Abstract:** To clarify the effect of Hindered amine light stabilizer (HALS) on ultraviolet (UV) aging behavior of asphalt binder, the evolution history and characteristics of the UV induced micro-structure of modified asphalt were characterized. Scanning Electron Microscope (SEM) and Atomic Force Microscope (AFM) were used to analyze the micro-morphology evolution of light stabilizer-modified asphalt during UV aging. By defining the micro-structure of asphalt in aging joints induced by UV, the identification and classification of typical micro-structure are proposed. On this basis, an evaluation method based on the morphology evolution process of modified asphalt aging was proposed to quantitatively analyze the effect of HALS on the UV aging of asphalt binder. The results show that the control effect of HALS on the UV aging behavior of asphalt can be verified by SEM and AFM detection methods. At the same time, the aging interval of the asphalt modified by hindered amine was divided by the method, and it was verified that the HALS could significantly prolong the service life of the asphalt binder. The micro-morphology of asphalt binder undergoes the process of crack generation

and propagation during UV aging. The micro-morphological changes of UV aged asphalt were interfered effectively by HALS, which could alleviate and control the development of UV induced micro-cracks, and promote the fusion of micro-cracks. This study provides an effective evaluation method for detecting UV aging micro-morphological evolution of HALS.

**Keywords:** UV aging, quantitative characterization, hindered amine light stabilizer

## 1 Introduction

Asphalt, as a high-viscosity organic material composed of hydrocarbons and their non-metallic derivatives, has been widely used as a pavement material in the field of road engineering [1]. However, when exposed to the elements such as light, heat, and water, the performance of asphalt pavement materials decreases. Especially under intense ultraviolet (UV) radiation, the chemical structure of asphalt pavement is damaged, which induces chemical reactions such as molecular alienation and dehydrogenation, accelerates the aging and cracking of asphalt pavement, seriously degrades the comprehensive performance of asphalt pavement, and makes the durability of asphalt pavement difficult to meet the design requirements [2, 3]. Therefore, controlling the road defects caused by UV aging of asphalt is the key to prolonging the service life of asphalt pavement.

At present, improving the anti-UV aging ability of asphalt is the main way to control the UV aging behavior of asphalt, which is achieved by adding various anti-aging agents [4]. The existing anti-UV additives include UV absorbent, antioxidant, composite-modified asphalt, or light stabilizers, among which Hindered amine light stabilizer (HALS) shows excellent anti-UV aging ability, can realize the extension of service life, and improve the use efficiency of asphalt roads [5–7].

Scholars at home and abroad have studied the anti-UV aging effect of HALS-modified asphalt. The results show

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# Aging And Behavior

**Marcia G. Ory, Ronald P. Abeles, Paula  
D. Lipman**



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*Aging and Behavior* Jack Botwinick, 2013-12-01      **Human Aging and Behavior** George Alexander Talland, 1968

**Insights in neurocognitive aging and behavior: 2022** Kristy A. Nielson, Annalena Venneri, Shin Murakami, 2024-01-30

**Behavior, Aging, and the Nervous System** Alan Traviss Welford, James E. Birren, 1965      Handbook of the Psychology of Aging James E. Birren, 2013-10-22 Handbook of the Psychology of Aging Third Edition describes the psychology of adult development and aging This book is organized into four parts encompassing 28 chapters that cover the basic behavioral changes and capacities occurring with advancing age The first part deals with the history concept and models of the psychology of aging This part also examines the distinctions between physical biological psychological and social time or age The second part explores the influences of racial ethnic and cultural factors on biological health social and psychological aging processes This part also surveys gender differences in aging The third part describes numerous behavioral processes changes and patterns in advancing age This part specifically considers the motivation cognitive and motor performance attentional processes learning memory personality and wisdom in aging The fourth part focuses on the applications of the concepts and principles of aging to the individual and society This book will be of great value to psychologists researchers and graduate students      **Handbook of Clinical Behavior Therapy with the Elderly Client** Patricia A.

Wisocki, 2013-11-21 Although we speak of the elderly as if there were one body of people with common characteristics older adults are more heterogeneous than any other population People over the age of 65 are also the fastest growing segment of the population in the United States currently numbering 25 million The majority of older adults reside in their communities a small fraction of them are cared for in institutions Most may expect to experience some kind of physical impairment Approximately a quarter of the population may expect to suffer a mental health impairment While traditional therapies have not been especially effective for older adults behavior therapy has shown exceptional promise as a treatment modality This book presents a comprehensive explication of the relatively new field of behavioral gerontology It was written for the clinician interested in the interaction of medical environmental and psychological variables and their effects on treatment of elderly clients and for the researcher who will be looking to extend knowledge about interventions with this population It will be useful for the graduate student in clinical psychology as well as the experienced clinician who will want to include the elderly in his or her therapeutic population      Aging, Health, and Behavior Marcia G. Ory, Ronald P. Abeles, Paula D.

Lipman, 1992 Drawing from both European and North American experiences this volume presents basic and applied research on ageing health and behaviour It points out the important role of individual behaviours societal conditions and public policies for determining the health of older people today and in the future The contributors explore the influence of age and ethnicity on health and behaviour coping with chronic illness and disability the effect of stress on illness disease prevention and health promotion and the implications for public policy      Research Awards Index , 1979      **The Graying of America**

Donald H. Kausler, 2001 Among other updates are more detailed coverage of health problems including arthritis diabetes osteoporosis and various kinds of cancer as well as advice on reducing the stress of caring for a family member with Alzheimer's disease BOOK JACKET Handbook of Applied Behavior Analysis Wayne W. Fisher, Cathleen C. Piazza, Henry S. Roane, 2021-07-14 Widely regarded as the authoritative work on the principles and practice of applied behavior analysis ABA this indispensable volume is now in a revised and expanded second edition Leading experts present evidence based procedures for supporting positive behaviors and reducing problem behaviors with children and adults in diverse contexts Chapters delve into applications in education autism treatment addictions behavioral pediatrics and other areas Covering everything from behavioral assessment and measurement to the design and implementation of individualized interventions the Handbook is a complete reference and training tool for ABA practitioners and students Key Words Subject Areas ABA therapy behavior analysts developmental disabilities autism spectrum disorders autism treatments behavior management functional behavioral assessments texts textbooks research handbooks positive reinforcement behavioral pediatrics behavioural behaviorism children adults principles and procedures graduate courses classes BCBA certification training reducing problem behaviors treating autistic kids behavioral treatments early interventions positive behavior supports comprehensive guide special education Audience Behavior analysts and trainees working with children and adults including special educators school and clinical psychologists autism specialists and behavioral medicine professionals *Behavior, Health, and Aging* Stephen B. Manuck, Richard Jennings, Bruce Rabin, Andrew S. Baum, 2014-04-08 A dramatic shift in the average age of the U S population and the increasing number of elderly Americans has introduced new and challenging healthcare dilemmas This book addresses these issues with contributed chapters by the leading authorities in the field of behavioral medicine It deals with health and healthcare needs of the elderly by considering basic changes that result from aging and some of the more specific problems that accompany it Content highlights include a review of the basic tenets of genetics and molecular biology including some of the methods of looking at heritable differences in health and well being Quality of life concerns are addressed including the differences between men and women as well as other gender issues Several chapters deal with the effects of aging on immunity The latter part of the book emphasizes the psychosocial implications of aging on cardiovascular disease Chronic illness among the elderly is also addressed Handbook of the Biology of Aging Edward J. Masoro, Steven N. Austad, 2011-04-28 The Handbook of the Biology of Aging Sixth Edition provides a comprehensive overview of the latest research findings in the biology of aging Intended as a summary for researchers it is also adopted as a high level textbook for graduate and upper level undergraduate courses The Sixth Edition is 20% larger than the Fifth Edition with 21 chapters summarizing the latest findings in research on the biology of aging The content of the work is virtually 100% new Though a selected few topics are similar to the Fifth Edition these chapters are authored by new contributors with new information The majority of the chapters are completely new in both content and

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**Aging and Motor Behavior** Andrew C. Ostrow, 1989 National Institute on Aging ... Report to Council on Program National Institute on Aging, 1980 *Aging Effects on Natural Fiber-Reinforced Polymer Composites* Chandrasekar Muthukumar, Senthilkumar Krishnasamy, Senthil Muthu Kumar Thiagamani, Suchart Siengchin, 2022-01-31 This book covers the topic of degradation phenomenon of natural fiber based composites NFC under various aging conditions and proposes suitable solutions to improve the response of natural fiber reinforced composite to aging conditions such as moisture seawater hygrothermal and natural and accelerated weathering The information provided by the book plays a vital role in the durability and shelf life of the composites as well as broadening the scope of outdoor application for natural fiber based composites The book will be appropriate for researchers and scientist who are interested in the application of natural fiber composites in various fields

Handbook of Models for Human Aging P. Michael Conn, 2011-04-28 The Handbook of Models for Human Aging is designed as the only comprehensive work available that covers the diversity of aging models currently available For each animal model it presents key aspects of biology nutrition factors affecting life span methods of age determination use in research and disadvantages advantages of use Chapters on comparative models take a broad sweep of age related diseases from Alzheimer's to joint disease cataracts cancer and obesity In addition there is an historical overview and discussion of model availability key methods and ethical issues Utilizes a multidisciplinary approach Shows tricks and approaches not available in primary publications First volume of its kind to combine both methods of study for human aging and animal models Over 200 illustrations

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